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Perspectives on Firm Decision Making During Risky Technology Acquisitions

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Abstract

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To answer these questions, hospitals were surveyed about the acquisition of their most valuable computed tomography machine. From the survey data, support was found for the Bounded Rationality hypothesis; firms have less uncertainty about an acquisition's performance on attributes that correspond to more strongly held objectives. Support was also found for the behavioral theory hypothesis; firms whose prior machines perform below aspiration levels seek more uncertainty in their subsequent acquisitions, while firms whose machines perform above aspiration levels seek less uncertainty. No support was found for the normative hypothesis; acquisition uncertainty is determined by economic attributes.

In the second comparison, partial support was found for the normative theory hypothesis and no support was found for Prospect Theory hypothesis. The value of the acquisition increased as the minimum lifespan of the acquisition increased. Perceived revenue, operating cost, and financial factor uncertainty did not significantly influence acquisition value, providing no support for Prospect Theory. However, greater uncertainty over the acquisition's ability to fulfill customer desires was associated with the acquisition of a less expensive machine.

Studies of the influence of uncertainty on capital investment decision making have traditionally focused on financial forms of uncertainty. The results of this study suggest that the influence of uncertainty related to an acquisition's ability to fulfill customer desires may have an even stronger influence on the value of an acquisition than variables related to the non-perceptual characteristics of the acquirer.

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PERSPECTIVES ON FIRM DECISION MAKING

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Adam C. Powell

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DEDICATION

I dedicate this dissertation to Barbara J. Cooper, Ph.D. and Robert C. Powell, M.D., Ph.D. — my parents. Hearing them say their names on their answering machine messages many times inspired me to seek to become "Dr. Powell" as well. Furthermore, without the help of Joel B. Karlinsky, M.D., M.B.A., none of this may have been possible. Finally, I dedicate this dissertation to the faculties of the MIT Program in Writing and Humanistic Studies and the MIT Sloan School of Management, where I completed my undergraduate training, and the Wharton School of the University of Pennsylvania, where I completed my graduate training. Without the assistance and mentorship of a large collection of individuals, this would not have been possible.

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ABSTRACT

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Lawton R. Burns, Ph.D., M.B.A.

A novel survey dataset on computed tomography (CT) machine acquisition is used to explore which theories best answer two questions from the decision making literature. First, what determines how much uncertainty a firm has when investing in updated technology? Second, what determines the value of the acquisition? In answering these questions, two theoretical comparisons are conducted. In the first, economic theory, behavioral theory (the Behavioral Theory of the Firm and Prospect Theory), and Bounded Rationality are tested as potential determinants of acquisition uncertainties. In the second, economic theory and Prospect Theory are tested as potential determinants of the value of the machine acquired.

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Chapter 1: Introduction

1.1: Problem Statement

In every technology-driven industry, firms must repeatedly make investments in equipment. As technology advances, firms research new technologies in an attempt to understand the implications for their businesses. Firms must decide both how much uncertainty they are willing to have about various performance attributes of the equipment and how valuable equipment they are willing to acquire. While there a number of competing views on how this occurs, they have all largely been tested separately. Thus, there is no clear consensus on which of the theories model reality the best.

This dissertation aims to answer two questions, which have been arranged as a two-stage model. First, what determines the amount of uncertainty a firm has about the technology that it acquires when it makes an acquisition? Second, what determines the value of the technology acquired? A number of different theories have been applied to both of these questions. This dissertation compares a selection of extant theories on the answers to these questions in order to determine which best hold within the context of a hospital's acquisition of a computed tomography (CT) machine. Unlike much prior research, it considers the impact of customer desires as well as financial factors on the acquisition process. Given that national hospital spending on equipment and infrastructure increased 1,800% over the past 40 years, understanding hospital capital investments is rapidly becoming more important (Hartman, Martin, Nuccio, & Catlin, 2010).

At least three competing perspectives exist on the determinants of the degree of uncertainty that firms experience when making investments under product uncertainty. The normative, economic perspective is to assume that the uncertainty in the decision is determined by externally-visible internal and environmental factors that exist at the time of acquisition (Achrol & Stern, 1988). In contrast, the behavioral perspective (Behavioral Theory of the Firm and Prospect Theory) argues that the degree of uncertainty a firm is willing to take on is codetermined by past performance, aspirations, and social comparisons (Cyert & March, 1963; Kahneman & Tversky, 1979). Finally, the Bounded Rationality perspective argues that the degree of uncertainty perceived is directly tied to the objectives held by the firm (Simon, 1947). Given these three competing perspectives, this paper aims to determine which one is most applicable to this context.

Likewise, there are at least two competing perspectives on the determinants of the value of technology acquisitions. Prospect Theory argues that uncertainty should play a role in determining the value of the technology selected, while the normative economic theory argues that the level of uncertainty should be irrelevant in determining the value of the acquisition. Instead, the normative theory suggests that the size of investments should be determined by measurable, non-psychological firm characteristics that influence revenues and costs. As no study of Prospect Theory using measures reported from within the firm has been conducted, it is unclear which perspective better predicts the value of an individual capital investment made by a firm. Using survey data collected from decision makers, this dissertation aims to determine which perspectives best predict both the uncertainty experienced during the acquisition process and the ultimate present value of the acquisition.

1.2: Choice of Context

Not all industries provide an equally good opportunity for studying capital investments by firms. In industries where there is an oligopoly or monopoly, it is not possible to study a large number of firms making similar capital investments. Fortunately, the hospital industry provides an interesting and suitable context for the study of firm investment decision-making. In the hospital industry, many firms produce similar services using similar sets of equipment. Matters are slightly complicated by the fact that some hospitals have for-profit missions, which others have non-profit missions, and that the customers of hospitals pay varying amounts due to insurance variation. Nonetheless, as hospitals compete for patients in part on a geographic basis, it is possible for a large number of hospitals to undergo similar investments. While the hospital industry contains adequate uniformity for comparisons to be made, the hospital industry also contains variation that causes different firms to make different investment decisions. Some hospitals have obligations to shareholders, while others have non-profit missions. Likewise, some hospitals exist in highly competitive urban environments, while others are rural monopolists. As a result of all this variation, it is possible to examine how firm characteristics influence the decision making process. Through surveying hospital employees, it is possible to examine how hospital objectives and perceptions influence the decision making process as well.

This study focuses on how hospitals acquire computed tomography (CT) machines because the acquisition of a CT machine is one of the single largest acquisitions a hospital makes. As many hospitals own multiple CT machines, they must go through this particular process over time. They likely go through a similar process when making other capital investments in costly technologies. While other imaging modalities like MRI and PET/CT are rather close comparators, the issues considered by this study are likely prevalent in the acquisition of other technologies, such as electronic medical records systems, as well. Although this study is healthcare-specific, purchasing is a topic of general interest that has been explored in number of industries, including aviation, food, plastics, and manufacturing (Lawrence & Lorsch, 1967; Puto, Patton, & King, 1985; McCabe, 1987).

Chapter 2: Theory & Hypothesis Development

As this dissertation aims to look at the determinants of capital investment uncertainty and at the magnitude of a capital investment in the context of hospitals investing in CT machines, it makes sense to explore the literature by moving from specific to general. I will start by discussing what is known about hospital investments in imaging technology before exploring what is known about how hospitals make investments in general. Afterwards, I review the literature on the determinants of investment uncertainty and uncertainty-seeking and on the determinants of investment value. By Section 2.4, it will be clear that the vast majority of the existing literature on hospital investment is based upon the examination of externally-measurable economic constructs, rather than upon behavioral and psychological constructs such as perceived uncertainty and objectives, which are most readily visible to those participating in the decision making process. Section 2.4 explores gaps in the hospital investment literature for which only research on other contexts has been conducted.

2.1: Previous Research on Investment in Imaging Equipment

A large portion of the literature on the adoption of imaging equipment focuses on the decision to adopt, rather than the size or nature of the investment itself. Magnetic resonance imaging (MRI) has more commonly been studied than CT, perhaps because adoption rates have been and still are lower for MRI than CT. (As this dissertation studies the acquisition, given that it has occurred, CT was selected due to its much greater prevalence.) Hillman and Schwartz (1985, 1986) counted existing CT and MRI installations within the United States and attempted to discern patterns in investment decisions and found that MRI was diffusing more slowly than CT. They speculated that uncertainties surrounding MRI technology, its medical utility, and its potential for reimbursement were hampering its diffusion relative to that of CT. Their speculation suggests that increased uncertainty on outcomes of an investment in a medical technology causes reduced investment. They authors further found that the Prospective Payment System and Certificate-of-Need regulation have both had a dampening effect on the adoption of MRI in hospitals, and have instead stimulated adoption by other types of organizations.

Others have studied MRI adoption as well. Teplensky, Pauly, Kimberly, and Hillman (1995) examined the adoption of MRI using a series of Cox regressions. Each regression attempted to determine whether a different motive explained hospitals' adoption of MRI. The motives considered were technological preeminence, clinical excellence, and profit maximization. These motives were picked, as they parallel the three decision systems which Greer (1985) claimed that hospitals use when adopting technologies: fiscal-managerial, strategic-institutional, and medical-individualistic. Self-reported measures of motive strength, as well as measures of concern about obsolesce, uncertainty about the type of MRI to acquire, and perceived importance of being a technological leader were included in the survey. They found that the likelihood of adoption was most strongly explained by the extent to which a hospital had positioned itself as being a technological leader. All three motives examined appeared to be relevant in determining the likelihood and timing of MRI adoption.

Likewise, Friedman and Goes (2000) examined the drivers of MRI adoption using the responses to a questionnaire and found that adoption appeared to be driven by market-related factors in California, but by physician championing in the Oregon/Washington region. The Oregon/Washington region was deemed to be a less turbulent environment than California, and it was found that organizational factors like size and decision maker influence played a stronger role in the adoption decision as a result. In a separate study that attempted to explain MRI adoption, Baker and Wheeler (1998) found that high HMO market share is associated with low MRI availability and usage—a finding they felt suggested that payers are able to influence the diffusion and utilization of technology.

The hospital technology adoption literature also includes papers not related to medical imaging. Kimberly and Evanisko (1981) examined the role that contextual, individual, and organizational factors played in the adoption of both administrative and technological innovations and found that the likelihood of adopting technological innovations was greater in younger and larger hospitals. In a similar vein, Romeo, Wagner, and Lee (1984) examined the diffusion of a variety of new (non-imaging) technologies, and found that interstate variation in prospective reimbursement programs influenced diffusion rates. This supports the notion that a relationship exists between the probability of adoption and the reimbursement system in place.

While the literature on hospital adoption of medical imaging equipment, and technologies in general, has closely examined the decision to adopt, thus far, it has only partially examined the determinants of both the value of the technology ultimately adopted and the role that uncertainty plays in the adoption process. As technologies such as CT mature, hospitals will increasingly go from making initial adoption decisions to making replacement decisions. This dissertation adds to the literature by examining hospitals who are primarily deciding what to adopt rather than whether to adopt.

2.2: Previous Research on Hospital Investment

Prior research on hospital investment has tended to examine how accounting variables such as operating costs and profit influence capital expenditures. The American Hospital Association's Annual Survey has provided control variables to much of the empirical literature, enabling the easy study of the influence of hospital control type, bed size, urbanicity, and expenditures on capital investment. Additional efforts to gain data on hospitals to better understand their investment have centered on determining hospital revenue and profitability, two variables not reported by the American Hospital Association.

There is an ongoing debate on the determinants of the size and nature of hospital capital investments. According to Anderson, Erickson, and Feigenbaum (1987), there is a conflict in the literature over whether a linkage exists between hospital capital expenditures and operating costs. Dunn and Lefkowitz (1978), Bentkover, Sloan, Feeley, Campbell, and Firth (1984), and Somers (1989) found evidence of a relationship between hospital capital expenditures and operating costs, while Dunkelberg, Furst, and Roenfeldt (1984) found little evidence of such a relationship.

Adding to this stream of research, Ginsburg (1970) found that hospital investment is explained by religious affiliation, hospital age, hospital size, and the amount of cash and assets restricted for improvement available. Anderson, Erickson, and Feigenbaum

(1987) concurred by stating that hospital bed size, ownership, wage levels, case mix, teaching status, and government regulations can influence both a hospital's capital investments and operating expenses. Meanwhile, Pauly (1974) found that hospital capital investment is a function of output changes and changes in physician net income. Bed size was more strongly linked to profitability than was hospital capital investment.

The literature also explores how profitability influences the decision to enter or exit an investment. Wedig, Hassan, and Sloan (1989) found that the entry and exit of for-profit hospitals is determined by reimbursement levels to a greater extent than in the case for non-profit hospitals. For-profit hospitals maximize their market value, which is defined as the sum of debt plus equity, while non-profit hospitals maximize the discounted present value of the utilities realized by hospital administrators, board members, and staff. For-profits obtain capital from retained earnings, stock issue, or debt issue, while non-profits obtain capital through retained earnings or debt issue. Cutler, Feldman, and Horwitz (2005) found that hospital profitability was not associated with computerized physician order entry (CPOE) investment. Government hospitals were the most likely to adopt CPOE, and for-profit hospitals were the least likely to adopt it. For-profit hospitals were also less likely to respond to the Leapfrog survey on adoption.

Another issue that the hospital investment literature examines with some detail is the factors that determine the extent to which a hospital uses debt. Sloan, Valvona, and Mahmud (1988) found that the cost hospitals paid for equity capital was much higher than inflation. The cost of debt capital was far lower. Wedig, Sloan, Hassan, and Morrisey (1988) found that a higher share of cost-based payments was associated with more leverage. Furthermore, they found that factors associated with a high risk of bankruptcy, such as earnings volatility, cause hospitals to take on lower levels of debt. Hospitals with greater percentages of their assets in tangible form take on more debt. There is also evidence that metropolitan hospitals take on more debt than rural or suburban hospitals (Anderson, Erickson, & Feigenbaum, 1987; Wedig, Sloan, Hassan, & Morrisey, 1988).

As debt financing is more affordable and universally available (unlike equity financing, which is not available to government and non-profit hospitals), it plays a larger role in the acquisition literature. Government hospitals, however, may behave different than for-profit and non-profit hospitals, as government hospitals have a soft budget constraint, while for-profit and non-profit hospitals do not. As a result of this budget constraint, Duggan (2000) found that for-profit and non-profit hospitals are equally responsive to financial incentives and no more or less altruistic than one another.

2.3: Previous Research on Firm Investment Uncertainty

While a rich literature on hospital investment exists, the extant literature largely focuses on readily-observable factors that are not psychological or behavioral in nature. Hospitals are but one type of firm. Fortunately, an even more varied literature exists on how firms make investments under uncertainty and on the magnitudes of the investments that firms make.

Although there may be other strands, I have identified three primary strands in the literature addressing the level of risk or uncertainty that firms take on with their investments (Figure 1). The first strand, the normative theory, has been developed by a series of economists. Similar to the literature mentioned in Section 2.2, the normative theory examines how concrete firm characteristics influence a firm's uncertainty during the investment process. The second strand, behavioral theory, examines how the gap between prior performance and prior aspiration levels influences a firm's willingness to take on risk or uncertainty in an investment. This literature was initially developed by Cyert and March (1963) as the Behavioral Theory of the Firm, then was substantially extended by Kahneman and Tversky (1979) as Prospect Theory, and then was further extended by Bowman (1980, 1982) as Bowman's Paradox. The third strand of literature is based upon the implications of Simon's (1947, 1951, 1952/1953, 1955) work on Bounded Rationality. This strand of literature posits that firms have limited time to assess their options. As a result, they must conduct a less vigorous search on some dimensions and focus on whether the various options meet their most strongly held objectives rather than simply on how well they meet all objectives in general.

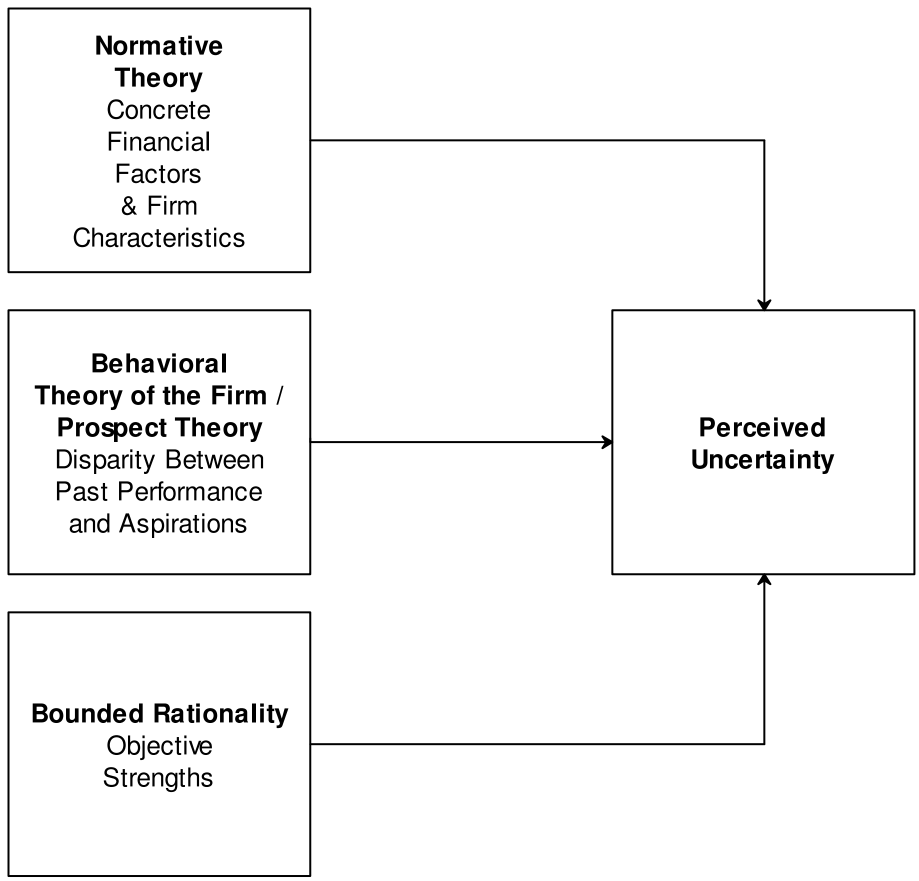

Figure 1: Three Potential Determinants of Perceived Uncertainty

2.3.1: Normative Economic Theory

Prior Normative Work on the Determinants of Uncertainty

A number of papers in the economics literature have examined the impact of uncertainty on firm capital investment through using metrics that are externally-visible and are economic rather than psychological in nature. While the papers largely do not focus on the determinants of uncertainty (treating uncertainty as a dependent variable), they define measures of uncertainty which are used as independent variables that are paired with measures of capital investment.

Leahy and Whited (1996) wrote an excellent review of the economic literature on the impact of uncertainty on investment. From their review, it is clear that study of the role of risk and uncertainty in capital investment decisions received substantial attention during the 1980s and early 1990s. Bernanke (1983) simply defined uncertainty as the spread in future outcomes. Hartman (1972) crafted a theoretical model for studying the influence of uncertainty on investment in which uncertainty was considered in future output prices, wage rates, and investment costs. Caballero and Pindyck (1993) and Pindyck and Solimano (1993) both examined the impact of uncertainty on irreversible investment through looking at the variance in the firms' marginal revenue product of capital as a proxy for uncertainty. Ferderer (1993) used the risk premium of corporate bonds as a proxy for the financial uncertainty that the firms faced. Hurn and Wright (1994) used variance in observed output prices (in their case, the price of oil) as a measure of price uncertainty. Normative models of the determinants of uncertainty tend to look at factors influencing uncertainty in profit through examining uncertainty in pricing (Hartman, 1972; Hurn & Wright, 1994), demand, costs (Hartman, 1972; Ferderer, 1993), or a combination these (Bernanke, 1983; Caballero & Pindyck, 1993; Pindyck & Solimano, 1993).

In the context of a hospital acquiring a CT machine, there are economic measures that reflect these variables. Pricing uncertainty comes from the payers. Different payers have different payment policies, and coverage and rates may vary over time. Demand uncertainty comes from the patients and referring physicians. For a CT machine to experience demand, people must desire, be able to afford and be able to access the machine's services. Costs are multi-faceted; CT machines have a fixed cost of installation, operating costs associated with servicing, and labor costs associated with providing the various services associated with their operation (operation by a technician, preparation of the patient by a nurse, interpretation by a radiologist, etc.). The relative impact of a change in most of these factors may be influenced by the overall size of the factor. Hospitals with more payer contracts may have less uncertainty about pricing, as no individual payer has as much pricing power when there are more payers. Likewise, hospitals with greater overall expenditures may have less uncertainty about operating costs, as they are better able to manage demand uncertainty without resorting to additional operating costs. (When firms have more employees, they tend to have more slack resources that can be shuffled to account for shifts in demand without paying overtime.) Additionally, hospitals with greater expenditures may have economies of scale. For instance, they may be able to spread the cost of a service technician over a larger number of pieces of equipment. Thus, any change in the cost of the technician will be reflected in a smaller change in the operating cost of the individual pieces of equipment. This leads to my first hypothesis:

> *Hypothesis 1: Uncertainty during the acquisition is influenced by measurable, non-psychological internal and external hospital characteristics.*

While testing my first hypothesis, I expect to find that hospitals with more numerous payer contracts will experience less uncertainty related to the revenues generated by their CT machines than hospitals with fewer payer contracts. Likewise, I expect to find that hospitals which have greater expenditures on facilities and labor will have less uncertainty in the operating costs of their most valuable CT machines.

Finding any relationship at all, regardless of sign, would support the notion that concrete firm characteristics are related to uncertainty. If this is the case, then the uncertainty I observed through my survey is a form of Knightian risk, in that it is easily quantified and determined by quantifiable measures (Knight, 1921). If a relationship is not found, it would suggest that the uncertainty that I measured may not be externally observable (or may not be observable using the measures I chose). If Hypothesis 1 is not supported, it would suggest that traditional economic measures would make the uncertainty reported on the survey appear to be a form of Knightian uncertainty – an unknowable unknown.

Nonetheless, it is quite possible that while the perceptions of uncertainty that I observed are quantifiable using non-economic, behavioral and psychological measures. To determine whether this is the case, Section 2.3.2 explores whether the uncertainty can be quantified using a behavioral measure and Section 2.3.3 explores whether the uncertainty can be quantified using a psychological measure. If the reported uncertainty can be quantified using any of these three types of measures, it would suggest that the respondents did not experience uncertainty while acquiring CT machines, but instead a form of Knightian risk (Knight, 1921).

2.3.2: Behavioral Theory of the Firm & Prospect Theory

Both Behavioral Theory of the Firm (Cyert & March, 1963) and Prospect Theory (Kahneman & Tversky, 1979) can be used to explain firm uncertainty-seeking. According to these perspectives, firms observe where they stand relative to where they wish to stand, and then choose a level of uncertainty accordingly. While both theories predict uncertainty-aversion when performance exceeds aspirations and uncertainty-seeking when performance fails to meet aspirations, the theories reach these common conclusions through different means. Nonetheless, they have been used in combination in a number of studies (Lant & Montgomery, 1987; Bromiley, 1991; Greve, 2003; Audia & Greve, 2006).

While these theories have traditionally been discussed within the context of risk, it is valid to discuss them within the context of uncertainty as well. Although the Behavioral Theory of the Firm is traditionally stated in terms of risk (measurable uncertainty), it has been examined within the context of uncertainty many times (Levinthal & March, 1981; Miller & Bromiley, 1990; Wiseman & Bromiley, 1996; Greve, 1998, 2003; Wiseman & Gomez-Mejia, 1998). Kahneman and Tversky (1992) stated that Prospect Theory is equally applicable to situations involving both risk and uncertainty. Thus, discussing these theories in the context of uncertainty is legitimate.

The Behavioral Theory of the Firm argues that past aspirations, past performance, and social comparisons drive a firm's present aspirations. Initial aspirations are created at the founding of the firm, and all present aspirations are henceforth iteratively determined as a function of prior aspirations, performance, and social comparisons. The firm then compares its current level of performance with its current aspirations and decides the extent to which it wishes to engage in a search for potential investments. The findings of Cyert and March (1963), are rather similar to those of Downey and Slocum (1975), who stated that variations in uncertainty arise from differences in cognitive processes, prior experiences, and social expectations.

According to the Behavioral Theory of the Firm, when searching for a solution for bringing performance to the level of aspiration, firms consider decisions associated with differing amounts of uncertainty. When firms have exceeded their aspiration level, they must still plot a course for the years ahead. As the desire to overcome failure is greater than the desire to increase success, firms take on more uncertainty when performing below their aspiration level.

In contrast, in Prospect Theory, the aspiration level is the firm's present situation and the firm judges whether the outcomes it experiences are successes or failures by measuring whether they are above or below this level (Audia & Greve, 2006). Prospect Theory suggests framing drives decision making behavior (Tversky & Kahneman, 1986, 1991; Thaler & Johnson, 1990). Prospect Theory predicts that firms will be uncertainty-averse when making decisions related to gains and uncertainty-seeking when making decisions related to losses (Kahneman & Tversky, 1979). When firms perform at below their aspiration levels, under Prospect Theory, this is perceived as a loss, which results in the firms increasing their uncertainty-seeking (Greve, 2003).

The Behavioral Theory of the Firm

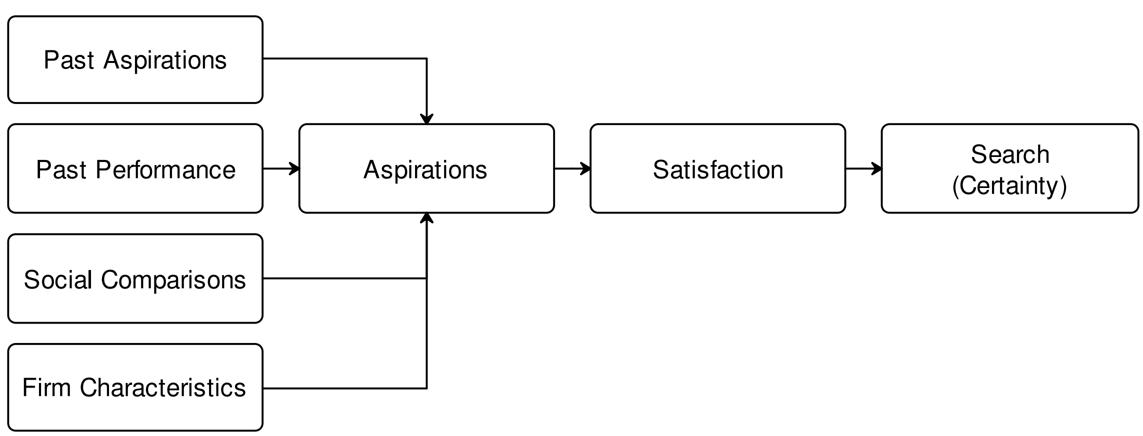

Figure 2: The Behavioral Theory of the Firm; Cyert & March (1963)

The Behavioral Theory of the Firm (Figure 2) suggests that firm aspirations are determined by past aspirations, past performance, social comparisons, and firm characteristics (Cyert & March, 1963). Aspirations drive a firm's satisfaction with its present state, which in turn drives the extent to which it searches for new, uncertain solutions, or attempts to preserve the status quo. While there are several components to the Behavioral Theory of the Firm, much of the resulting research has focused on how the discrepancy between firm aspirations and performance influence firm behavior (Cyert & March, 1963; March & Shapira, 1987, 1992; Bromiley, 1991; Harris & Bromiley, 2007). There is consensus that for firms performing above aspiration levels become more uncertainty-averse, but there is disagreement on whether firms performing below aspiration levels become more uncertainty-seeking (Cyert & March, 1963; Wright & Kunreuther, 1975; Kahneman & Tversky, 1979; Bowman, 1980, 1982; Bromiley, 1991) or more uncertainty-averse the further performance deviates from aspiration levels (Janis & Mann, 1977; Staw, Sandelands, & Dutton, 1981; Sitkin and Pablo, 1992).

Nonetheless, some authors have proposed that more complicated relationships exist. Greve (1998) argued that whether firms make greater or fewer changes as their performance falls further from the aspiration level is dependent on the nature of the change. Firms have a higher probability of making some types of changes, but a lower probability of making others as their performance falls further behind. However, he found that firms far more dramatically decrease their likelihood of enacting change if their performance exceeds aspiration levels. Subsequently, Audia and Greve (2006) argued that the relationship between below-aspiration performance and uncertainty-seeking is moderated by the size of a firm's stock of resources. They found that shipbuilding firms with smaller stocks of resources took on less uncertainty when underperforming in order to avoid failure, while shipbuilding firms with larger stocks of resources took on more uncertainty when underperforming in order to attempt to restore performance to the aspiration level.

The distance between a firm's prior performance and aspiration levels is in part determined by how aspiration levels are set. There has been slight variation in how March has defined the determinants of aspiration levels across his canon of papers. March and Simon (1958) suggested that aspirations are determined by both past performance and social comparisons. Cyert and March (1963) subsequently suggested that aspiration levels are a function of past performance, social comparisons, and previous aspiration levels. Levinthal and March (1981) simply defined present aspirations as a weighted sum of past aspirations and past performance.

To further complicate matters, the relative performance of firms has been measured in several ways as well. Relative performance historically has been measured by either combining a firm's own performance and the performance of its peers into one measure (Bromiley, 1991; Wiseman & Bromiley, 1996; Wiseman & Catanach, 1997; Greve, 2003), or through handling both types of performance separately (Greve, 1998; Harris & Bromiley, 2007). In some papers (Bromiley, 1991; Wiseman & Bromiley, 1996; Wiseman & Catanach, 1997), social comparisons have been used as the firm's reference point for performance below aspirations, while self-comparisons have been used as the firm's reference point for performance above aspirations. The logic behind doing so is that firms no longer refer to their competitors when setting goals if their performance exceeds that of their competitors. If this were not the case, high-performing firms might set future aspiration levels below their current level of performance.

Bowman's Paradox

In a series of two papers published in Sloan Management Review, Bowman (1980, 1982) presented a paradox that was the basis of much further research on the Behavioral Theory of the Firm and Prospect Theory at the firm level. Bowman found that there is a negative correlation between risk and return. While intuitively, one would expect that greater risk taking by firms would have to be rewarded with greater returns in order for firms to be willing to take the greater risks in the first place, Bowman found the opposite to be the case. He suggested that the return on risk might be in part determined by the fact that better performing companies may be less desperate for investment opportunities, and thus less willing to take less favorable risks. In his 1982 paper, Bowman used a variety of data sources to show that troubled companies are more risk-seeking than healthy companies, which may be the cause of the association between higher risk and lower return. In the paper, Bowman commented that this behavior is similar to the behavior demonstrated by individuals under Prospect Theory. Bowman noted a laboratory study conducted by Laughhun, Payne, and Crum (1980), in which it was found that managers were risk-seeking for below target returns, except when at risk for a ruinous loss. This finding was stable for managers from a variety of backgrounds, and held regardless of whether the decision was over a personal or managerial investment.

In a later set of papers, Fiegenbaum (Fiegenbaum & Thomas, 1986; Fiegenbaum, 1990) used industry-level data to test Bowman's Paradox. Fiegenbaum and Thomas

(1986) found that when using accounting measures of risk and return, Bowman's Paradox held during the 1970's, but not the 1960's. When they instead used market-based measures of risk and return, the Paradox disappeared completely, as the market compensated for the Paradox. Firms with relatively low levels of risk compared to their return were priced higher by the market. In a follow-up study, Fiegenbaum (1990) found that Prospect Theory could be used to explain how firms made trade-offs between risk and return. Namely, organizations performing below their industry average return on assets tended to be risk takers, while those performing above their industry average tended to be risk averse. Furthermore, the slope of the risk-return trade-off was about three times as large for firms below their industry average as it was for firms above their industry average. Additional support was found for these conclusions by Bromiley (1991), who found that poor firm performance resulted in increased risk taking, and that these risks appeared to result in even further poor performance. The poor performance of the risky investments made by the poorly performing firms held even after controlling for industry performance, past firm performance, and organizational slack. In a subsequent study, Wiseman and Bromiley (1996) found that among organizations in decline, risk taking was associated both negatively with performance and positively with decline.

Testing the Theories

As this review has shown, many studies have modeled aspirations as being determined by both prior aspiration levels and prior performance (Cyert & March, 1963; Lant & Montgomery, 1987; Levinthal & March, 1981; Lant, 1992). In these studies, aspirations automatically adjust upwards as performance improves and downwards as performance declines. Unlike these prior studies, this study relies upon a self-reported combined measure of past performance and past aspiration. The Behavioral Theory of the Firm literature tends to rely upon externally-visible indicators of both aspirations and performance which may or may not be held or directly compared by individuals within the firms in question. By directly asking decision makers how much their firm's performance deviated from their aspirations, it is possible to ensure that they have considered both past aspirations and past performance in combination.

Given the relative lack of clarity that surrounds the determination of aspiration levels and relative performance, this dissertation attempts to skirt the issue entirely. Instead of attempting to measure absolute performance, social performance, and prior aspiration levels, I have simply asked firms about the extent to which their prior CT under-performed or out-performed in comparison to their aspirations for the machine. The prior most valuable CT machine acquired by the hospital is used an anchor, as the literature shows that firms anchor on their prior aspirations and performance when setting new aspirations. Incremental change is a decision rule that reduces the amount of information that needs to be processed for a decision to be made (Levinthal & March, 1981; Lant, 1992). Thus, aspirations change with performance. To test whether the prior literature on the performance-aspiration disparity holds in this context, I hypothesize:

Hypothesis 2: Uncertainty during the acquisition is negatively influenced by the disparity between the firm's aspirations for the prior acquisition and the performance of that acquisition.

If prior performance exceeds aspirations for each of the CT attributes, I expect to see hospitals invest in machines associated with less uncertainty on the corresponding attributes, while if prior performance falls short of aspirations, I expect to see hospitals invest in machines associated with more uncertainty on the attributes in question.

2.3.3: Bounded Rationality Theory

It is possible that there is a third explanation for firm uncertainty during the acquisition process. In addition to stemming from firm characteristics or the firm's choice to seek uncertainty, it may also stem from limits on the firm's ability to reduce uncertainty. Bounded Rationality (Simon, 1955) suggests that firms have simple, somewhat binary, pay-off functions and are constrained in their ability to search for solutions. As pay-offs may be determined by multiple, difficult to compare attributes (i.e. revenues, physician satisfaction, and research output in the case of CT machines), firms may elect to search for viable solutions that satisfice on all the necessary attributes, and then attempt to find the best possible satisficing solution (Simon, 1951, 1952/1953).

While traditionally, the study of Bounded Rationality has looked at the behavior of firms, rather than that of divisions (in this case, the Department of Radiology), there is an empirical reason to believe that Bounded Rationality is applicable here. Respondents to the survey on which this study was based were asked whether their radiology department maintained a profit and loss statement. As 72% of respondents claimed that their radiology department maintained its own record of its profitability, there is reason to believe that the radiology departments are essentially miniature firms operating within a larger ecosystem. Thus, this observed behavior suggests that Bounded Rationality may be applicable in this context as well.

There is some debate over whether the views Simon expressed are correct. March (1978) stated that when tastes appear in prescriptive theories of choice, they are absolute, relevant, stable, consistent, precise, and exogenous, and noted that each of these properties of tastes appears to be inconsistent with observations of individuals and institutions. March continued by stating that we avoid our preferences, and that we are prepared to act in ways inconsistent with our preferences. Furthermore, he stated that "we specify goals that are different from the outcomes we wish to achieve".

If March (1978) is correct, there should be no relation between a firm's uncertainties and a firm's objectives. Firms with inconsistent preferences varying wildly over time would perform pre-acquisition research to decrease uncertainty about objectives different than the ones held at or after the time of acquisition. Meanwhile, if Simon (1951, 1952/1953, 1955) is correct, if firms have consistent preferences and are constrained in their abilities to search, they should search more extensively along objectives of greater importance to them and less along objectives of lesser importance to them. If this is the case, the result should be that higher objective strength leads to lower objective uncertainty for each of the objectives. Hypothesis 3 tests whether March's (1978) statements about the inconsistence of preferences are correct, or whether instead preferences are consistent and uncertainty reduction activities are most strongly concentrated on the strongest objectives, as is suggested by Bounded Rationality.

Hypothesis 3: Uncertainty during the acquisition is negatively influenced by the objectives the firm held for the acquisition.

Prior Research on Objectives and Their Relationship to Uncertainty

Before testing Hypothesis 3, it is important to precisely define what objectives are and to explore what is known about their relationship with uncertainty. Both a goal and an objective may be defined as "a desired direction or state that guides behavior" (Carlson et al., 2007). The objectives examined in this study are all consumption objectives; namely, how a CT machine will influence a hospital's revenues, costs, physician and consumer preference fulfillment, quality of care, and research. Van Osselaer et al. (2005) wrote that "consumers choose products for the benefits they afford, not the attributes they contain." Thus, it seems very appropriate to cast the objectives in terms of CT benefits, and not in terms of CT properties, such as number of slices or physical size.

Objectives and objective setting has long been a topic examined by the fields of behavioral economics (Tversky, Sattath, & Slovic, 1988; Slovic, 1995; Krantz & Kunreuther, 2007) and micro-organizational behavior (Vroom, 1964; Locke & Lantham, 1990; Wright et al. 1993). There is also an extensive theoretical literature (Debreau, 1960; Krantz, Luce, Suppes, & Tversky, 1971; Keeney & Raiffa, 1976) and empirical literature (Kunreuther, 2008; Barseghyan, Prince, & Teitelbaum, 2009; Hardisty & Weber, 2009; Laury, McInnes, & Swarthout, 2009; Burmeister-Lamp, Lévesque, & Schade, 2010; Schwarcz, 2010) on decision making when there are multiple objectives. Several good reviews of the multiple objective decision making literature have also been written (Leeds, 2006; Weber & Johnson, 2009; Warren, McGraw, & Van Boven, 2010). As a result, there is some evidence from the literature suggesting that a connection exists between uncertainty and objectives. Nonetheless, many papers suggest the opposite causal direction from the one suggested by Bounded Rationality. That is, they suggest that uncertainty drives objectives, rather than that objectives drive uncertainty. For instance, Bourgeois (1985) found that while the number of objectives held by a firm has nearly no relationship to a firm's actual environmental volatility, firms that perceive more environmental uncertainty have significantly more objectives. Thus, the number of objectives held is more determined by the perceived uncertainty, rather than by the actual uncertainty in the environment. Nonetheless, the number of strategic objectives held by a firm was found to have no relationship with its performance.

Another study that connected uncertainty to objectives was Cox and Rich (1964). They found that the amount of risk a woman perceived in buying items over the telephone was related to her objectives when buying. Items used in the home, such as bed linens, were perceived as less risky to buy over the telephone than items like shirts, as bed linens are often purchased to meet utilitarian objectives while shirts are purchased to meet fashion-related objectives. In general, perceived risk was found to be determined by the buyer's subjective certainty that she would win or lose some of what was at stake. Likewise, Mitchell (1998) examined the relationship between perceived risk and buying objectives in the context of grocery shopping, using the model of perceived risk proposed by Cunningham (1967), in which total perceived risk was in part related to the number of sources of adverse consequences considered. These studies imply that if there is more uncertainty surrounding an item's ability to meet the most important objectives behind its purchase, the purchase will be perceived by the consumer as overall more uncertain and will be less likely to occur.

The testing of Hypothesis 3 will help affirm whether a relationship exists between firm objectives and uncertainty. While it will not be possible to determine the causal direction, it will be possible to determine whether a relationship exists. If a relationship is found, one possible explanation might be the one suggested by Bounded Rationality – greater objective importance is associated with less uncertainty surrounding the objective due to the greater investment of effort in conducting a search and reducing uncertainty related to the objective in question. The empirical literature also suggests that the opposite causal direction might be possible as well (Cox & Rich, 1964; Bourgeois, 1985; Mitchell, 1998).

When the results of the tests of Hypotheses 1, 2, and 3 are compared, it will be possible to get a better understanding of the factors that determine firm uncertainty during the acquisition process. It is possible that multiple models will to some extent explain firm uncertainty during the acquisition process. If this is the case, the most relevant model can be determined by looking at the fit of the models. Even if this occurs, there is value in knowing whether there are multiple explanations for firm uncertainty during the technology acquisition process.

2.4: Previous Research on the Determinants of Investment Value

Section 2.3 examined the determinants of the amount of uncertainty that firms face when making investment decisions. This section builds upon that by examining whether concrete financial factors and firm characteristics or uncertainty measures do a better job of explaining the present value of a hospital's most valuable CT machine. As is depicted in Figure 3, this section will compare two potential explanations for the present value of the acquired machine.

The two competing determinants of CT present value tested in this model are meant to parallel the constructs from the comparison in the prior section as much as possible. The concrete factors used to test the normative model are the same ones used in the prior section. Likewise, the measures of perceived uncertainty used as independent variables in this section are the same measures that were used as dependent variables in the prior section.

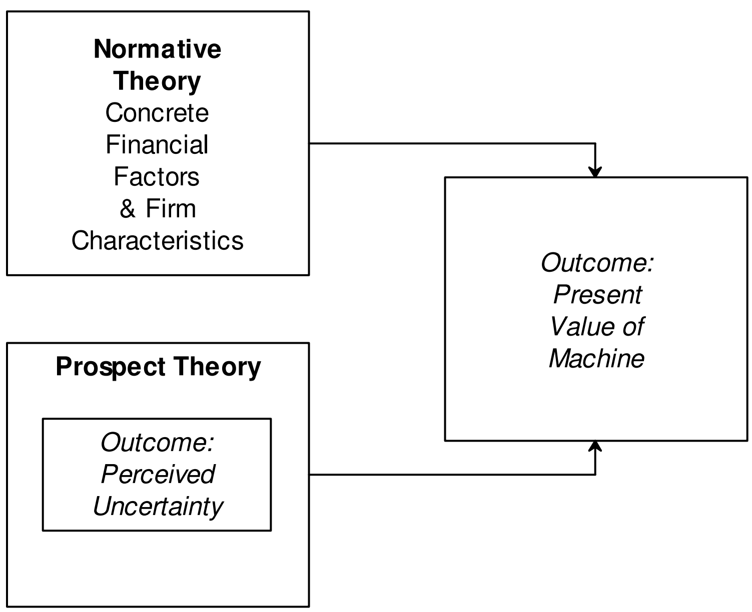

Figure 3: Two Potential Determinants of Acquisition Value

2.4.1: Normative Economic Theory

Profit Maximization

The normative economic theory of how for-profit hospitals make investment decisions is that of profit maximization (Wedig, Hassan, & Sloan, 1989). Namely, firms pursue the portfolio of investments that has the greatest possible Net Present Value (NPV). To do this, for each investment, they must estimate the expected revenue in each time period, the expected costs in each time period, the discount rate, and the time horizon of the investment. Differences in the distributions of revenue and cost outcomes are ignored; only expected values are considered. As revenues, costs, and time horizons differ from machine to machine, different CT machine investments have different Net Present Values. Under economic theory, profit maximizing firms should invest in the CT model with the greatest Net Present Value. It should be noted that strictly profit maximizing firms do not consider their uncertainty when making acquisition decisions. As the expectations of the variables in the model are used to derive the Net Present Value of the acquisition, the distributions of the variables themselves are not relevant to the decision making process.

Purchasing versus leasing CT machines results in a slightly different Net Present Value formula. When machines are purchased, hospitals undergo either a large fixed cost in the year of purchased, or a stream of recurring costs for a fixed period, if debt financing is used. When machines are leased, hospitals must pay recurring lease payments. In some leases, these payments are made on a periodic basis (i.e. monthly billing), while in other leases, these payments are made based upon utilization (i.e. pay-per-scan).

The two formulas below illustrate the formulas for determining the Net Present Value (NPV) of a purchased and leased CT machine, with an operational life of *t* years. Note that when the machine is purchased, the cost of the machine is experienced at the time of purchase, and thus is not discounted. Under the lease, if payments are uniform, the lease payment will be discounted more and more over time.

$$NPV(purchase) = -machine\ cost + \frac{usage * (average\ price_1 - marginal\ operating\ cost_1) - fixed\ operating\ cost_1}{(1+r)^1} + \cdots + \frac{usage * (average\ price_t - marginal\ operating\ cost_t) - fixed\ operating\ cost_t}{(1+r)^t}$$

$$NPV(lease) = \frac{usage * (average\ price_1 - marginal\ operating\ cost_1) - fixed\ operating\ cost_1 - lease\ payment}{(1+r)^1} + \cdots + \frac{usage * (average\ price_t - marginal\ operating\ cost_t) - fixed\ operating\ cost_t - lease\ payment}{(1+r)^t}$$

The decision between buying and leasing can be made by comparing the present value of the two. When buying or leasing, a firm should keep in mind its alternative potential uses of the capital. The upfront cash saved from leasing instead of purchasing can be invested or can be used to pay off other debt. Tax implications may also influence the decision. While lease payments are a deductible expense when determining income subject to taxation, only the interest expense of a loan is a deductible expense. Thus, the size of the lease payments, the useful life of the asset, the tax rate, the interest rate for borrowing capital, the salvage value of the asset if purchased, and any differences in operating costs between a leased or purchased asset will all figure into the decision as to whether equipment should be leased or purchased (Johnson & Lewellen, 1972; Gorton, 1974). When the duration for which a piece of equipment will be used is unknown, a lease with an uncertain life may be preferable (Bierman & Smidt, 1984).

While profit maximization is the normative model of how firms make investments, it is not testable due to the limitations of the data available. The pilot study that was conducted revealed that respondents had great difficulty estimating their hospital's CT usage. As pricing, profit, and revenue information is confidential due to its use in negotiations with insurers, no such information was available in the American Hospital Association database. Likewise, questions on pricing were not included on the survey in order to not adversely influence the response rate. Thus, it is not possible to determine what the profit of the acquired machine ultimately was. Furthermore, since information was not obtained about other CT options which were not selected, it is not possible to tell whether hospitals acted in an NPV-maximizing fashion. The only elements of the NPV formula that are known are those that relate to machine cost and operational time horizon.

Incorporating Risk into an Economic Model of Investment

The economic literature proposes a number of techniques that can be used to deal with risk in cash flows (Bierman & Smidt, 1984; Bierman, 1986). Ultimately, only expectations enter into the measure of profitability used (i.e. Net Present Value or Internal Rate of Return). For each period of the investment, the decision maker can enumerate all the possible events, their probability of occurrence, and their magnitude, and then can determine the expected value in that period. Uncertainty – immeasurable risk – cannot be incorporated into economic models of cash flows, as by definition, taking the expectation of uncertain variables is impossible.

When estimating profit, if certain events can only occur in certain sequences, a series of rules can be devised and then the outcomes can be simulated. Observation of the simulations or prior real-life events can be used to build a probability distribution (Hillier, 1963). Sensitivity analyses can also be performed. The values in a model can be adjusted for risk by adjusting the discount rate or substituting certainty equivalents for the values of risky outcomes. The Capital Asset Pricing Model (CAPM) can be used to estimate the required return for any investment (Sharpe, 1964).

When modeling the cash flow of an investment under uncertainty, it is essential to incorporate the salvage value of the investment. That is, the revenue and cost implications of abandoning the investment in the event that it does not work out must be incorporated into either the calculation of Net Present Value or Internal Rate of Return (Johnson, 1994). CT equipment has a non-zero salvage value, as it is traditionally resold outside of the U.S. once it surpasses its useful life to its original owner.

Prior Research on the Normative Determinants of Investment Value

The normative literature suggests that when making investments, hospitals should consider factors influencing the revenues, costs, time horizon, and interest rate associated with their investments (Johnson & Lewellen, 1972; Gorton, 1974). After examining the investment processes of a number of firms, Bromiley (1986) stated that the cash flow equation plays a large role in corporate investment decisions. All of the firms he studied used hurdle rates to evaluate and compare the profitability of investments, and rarely changed these hurdle rates more than once every five years. While the firms that Bromiley observed attempted to make investments that were as profitable as possible, they were constrained by the availability of acceptable investments, the availability of funds, and the capability of the firm to execute on the investments.

Although it is not possible to directly measure the revenues or operating costs that the hospitals experienced in connection with their CT machines, the healthcare literature contains many findings on factors influencing revenues and costs. Zwanziger and Mooney (2005) found that hospitals in markets with more concentrated managed care payers got paid less as a result of the increased negotiating power possessed by the payers. Supporting this finding, Sorensen (2003) found that payer size influences market power. However, Dranove, Shanley, and White (1993) had the contradictory finding that HMOs and PPOs were not able to substantially influence prices within concentrated hospital markets. Thus, while there is some evidence that payer contracts may play a role in the ultimate value of the investment, the evidence is not conclusive.

There is also evidence from the literature on the influence of costs on investment. Ladapo, Horwitz, Weinstein, Gazelle, and Cutler (2009) found that hospitals with higher operating margins were more likely to adopt advanced CT machines. Hospitals with higher operating margins have more financial wiggle-room with which to handle lags that it may take for reimbursement levels to cover the higher costs of more advanced imaging technology. Thus, operating margins may be relevant to the adoption decision.

However, the cost of capital, as reflected by the interest rate, may not influence investment as might be suspected. Graves (1988) did not find a significant relationship between the interest rate and R&D expenditures, and several others have found that leverage encourages risk-seeking behavior when debt is not appropriately priced to reflect the risks of the investments for which it will be used (Jensen & Meckling, 1976; Barnea, Haugen, & Senbert, 1985). Leverage may even encourage risk-seeking behavior (Wiseman & Catanach, 1997). This is a disconcerting finding, as investments made at rates of return below the discount rate are harmful to stockholders (Elton, 1970). These findings would all suggest that lower interest rates may be associated with larger investments.

As a result of these findings, the economic literature seems to suggest that the size of a hospital's investments will be in part determined by a combination of the diversity of its revenue sources, the magnitude of its other costs, and the interest rate that it faces at the time of investment. Thus, I hypothesize:

Hypothesis 4: The present value of the acquisition is influenced by measurable, non-psychological internal and external hospital characteristics.

In testing this hypothesis, I will look at the diversity of payers, the magnitude of costs, and the interest rate faced by the hospital at the time of acquisition. I expect that more payer contracts, greater overall expenditures, and lower interest rates at the time of acquisition will all be associated with acquisitions having higher present values.

2.4.2: Prospect Theory

Just as Prospect Theory (Kahneman & Tversky, 1979) was used to explain the magnitude of uncertainty firms have during investments (Section 2.3.2), it may again be used to explain the magnitudes of the investments themselves. Prior studies related to Prospect Theory have shown that people tend to be uncertainty-seeking when facing uncertainty in the loss domain and uncertainty-averse when facing uncertainty in the gain domain. While Prospect Theory has not been studied in the context of corporate investment decisions, MacCrimmon and Wehrung (1986) found that executives presented hypothetical investment gambles were more risk-seeking for threats than they were for opportunities, regardless of whether making decisions for themselves or their businesses. Furthermore, Schoemaker (1991) found evidence that the effect of uncertainty on utility is not symmetrical around zero; people's distaste for uncertainty in the probability of winning a gamble is greater in the gains domain than in the losses domain. Studying whether Prospect Theory influences the size of acquisitions in this particular context is important, as it has been shown subjects evaluate risk differently depending on context (Hershey & Schoemaker, 1980). Thus, it is possible that findings on investment behavior under risk in other contexts may not be generalizable to this one.

Uncertainty-aversion Due to Managerial Discretion

In addition to Prospect Theory, there is another possible explanation for general uncertainty-aversion in the investment decisions made by hospitals. Managerial desire for self-preservation induces uncertainty-aversion, regardless of the domain. Although the investors in for-profit hospitals or charitable or government sponsors of non-profit hospitals may wish for their hospitals to be uncertainty-seeking, decision makers within the hospitals are likely to be uncertainty-averse, as they are unable to protect themselves against firm-specific adverse outcomes through creating a portfolio of investments (Coffee, 1986; Greenwald & Stiglitz, 1990). Decision makers may act in a way that minimizes personal potential for loss of employment (Gupta, 1987, Chatterjee & Lubatkin, 1990; Wiseman & Gomes-Mejia, 1998). While an investor may invest in multiple for-profit hospitals and a charity or government entity may contribute to multiple non-profit hospitals, decision makers employed by the hospitals themselves have a lot to lose if their particular hospital becomes financially-distressed. In other contexts, it has been shown that corporations purchase insurance against losses in order to protect their management teams from the downside outcomes, to enable less uncertainty-averse decision making (Mayers & Smith, 1982).

There is evidence that decision makers' actions are influenced by these biases. Alchian and Kessel (1962) found that in less competitive markets, decision makers are able to maximize a preference function other than a profit function. Williamson (1963) found that decision makers have a preference towards costs that are likely to directly benefit them over costs that are not. Given that many hospitals operate in remote geographic markets and openly have preference functions other than that of profit maximization (i.e. government and non-profit hospitals), it is likely that Alchian and Kessel's finding holds in the context of hospital equipment acquisition as well, and that decision makers are able to behave in a manner that suits their interests rather than one that maximizes the profit of the hospital. Nonetheless, managerial concerns do not explain why in some contexts, uncertainty-aversion is associated with gains and uncertainty-seeking is associated with losses. While managerial self-preservation would explain an association between uncertainty and investment, the association they suggest is uniformly uncertainty-averse.

Prior Research the Impact of Uncertainty on Capital Investments

The Prospect Theory literature on investments tends to look at investments made by individuals. While the Bowman's Paradox (Bowman, 1980, 1982) literature looks at Prospect Theory from the context of a firm, it examines risk taking rather than capital investment. Most of the extant literature on the role of uncertainty in capital investments comes from the field of economics. Economic research on this topic largely began with Hartman (1972), who found that in a theoretical context, current investment does not decrease with increased uncertainty in future output prices and wages, and is invariant with uncertainty in future investment costs. Pindyck (1982) demonstrated using a theoretical model that uncertainty increases a risk-averse firm's desired level of capital stock if the marginal cost of adjustment is rising at an increasing rate. Abel (1983) demonstrated that although Hartman (1972) and Pindyck (1982) had somewhat different results, Hartman's results continue to hold using Pindyck's stochastic specification. Overall, Abel found support for the assertion that increased uncertainty causes increased investment.

Over time, two competing views on the relationship between uncertainty and capital investment have emerged within the economics literature (Caballero, 1991). On one hand, there is evidence that the two have a negative relationship (Bertola, 1988; Pindyck, 1988; Craine, 1989; Zeira, 1989; Caballero, 1991), and on the other hand there is evidence that the two have a positive relationship (Hartman, 1972; Pindyck, 1982; Abel, 1983, 1984, 1985). Ultimately, the relationship found appears to be highly sensitive to the specification of the model in the paper.

A number of papers from behavioral theorists have examined how uncertainty and framing influence individual investment decisions in the context of Prospect Theory. Kahneman and Tversky (2000) compiled an anthology of papers providing support for support for Prospect Theory. Their anthology contained many papers which were empirical in nature and dealt with individual decision making. One included paper, Johnson, Hershey, Meszaros, and Kunreuther (1993), found framing substantially influenced how people evaluated purchasing decisions. A disability policy featuring a rebate was preferred over a policy without a rebate, even though the rebateless policy had a lower expected cost. It was suggested that this occurred because the decision makers evaluated the losses and gains associated with the policy separately using non-linear value functions, rather than simply taking the expected value of both policies. Further evidence for the separate evaluation of gains and losses due to mental accounting was provided by Thaler (1999). As a result of these findings, it makes sense to separately consider how uncertainties related to revenues and costs influence investment.

The empirical support for Prospect Theory predicting investment decision making in situations in which Expected Utility Theory fails is rather strong. Camerer (2000) summarized the literature on the topic and noted supportive prior findings related to the relative returns of stocks and bonds (Benartzi & Thaler, 1995), stock holding and selling behavior (Odean, 1998; Genesove & Mayer, 2001), and single product consumer purchases (Hardie, Johnson, & Fader, 1993). Thus, empirical support for Prospect Theory stems from multiple domains.

Nonetheless, there is empirical evidence that people do not always make their investment decisions in accordance with Prospect Theory. Kalayci and Basdas (2010) found that professional power traders did not treat gains and losses differently when making investment decisions, nor did the history of their outcomes influence their decision making, in direct opposition to the findings of Thaler and Johnson (1990). Gneezy, List, and Wu (2006) found an even more puzzling violation of Prospect Theory in which people's willingness to pay for a lottery consisting of two prizes was less than their willingness to pay for either prize on its own. For instance, people were willing to pay more for a $50 gift certificate than for a lottery with a 50% chance of winning a $50 gift certificate and a 50% chance of winning a $100 gift certificate. This finding, which they dubbed the *uncertainty effect*, fits with neither Expected Utility Theory nor Prospect Theory. If the uncertainty effect applies to equipment acquisition, it is possible that greater decision maker uncertainty will be associated with lower acquisition values, even if the worst possible outcomes estimated by the uncertain decision makers are better than those estimated by more certain decision makers.

Extending Prospect Theory to Equipment Acquisition

Prospect Theory, as introduced by Kahneman and Tversky (1979), proposes a utility function for the interpretation of outcomes which is concave for gains and convex for losses, causing uncertainty-aversion in gains and uncertainty-seeking in losses, with a loss of one unit causing more disutility than the utility provided by a gain of one unit. Prospect Theory suggests that for each facet of a multifaceted investment, firms will prefer low uncertainty related to the facet if they view it as a gain, and high uncertainty if they view it as a loss. While Kahneman and Tversky suggested that decision makers combine valuations of different aspects of an investment through "mental editing", it is unclear how decision makers edit together gains and losses that pertain to substantially different units. Revenues and costs are measured in dollars, care is measured in quality-adjusted life years (QALYs), and preference fulfillment is often measured through self-reported measures of satisfaction. Thus, rather than examining how an aggregate measure of uncertainty impacts acquisition value, it makes sense to examine how different types of uncertainty each impact the present value of the acquisition. Examining one type of uncertainty at a time eliminates the problems posed by aggregation.

Perhaps one reason that firm uncertainty in the context of a self-reported measure has not been previously examined is because it is hard for firms to report. During my pilot study, I attempted to determine both the skewness and means of the uncertainties perceived by the respondents. The respondents had difficulty providing responses to the questions. As a result, I only asked about the perceived degree of uncertainty on the ultimate instrument. Although this is a crude measure, it does facilitate examining how variation in perceived uncertainty impacts the present value of the machine ultimately acquired. As a result of these measurement issues, my test of the influence of uncertainty on acquisition value is simply the following:

Hypothesis 5: The present value of the acquisition is influenced by the acquirer's perceived uncertainty about the acquisition before it takes place.

In testing this hypothesis, multiple types of perceived uncertainty will be examined. I hypothesize that increased revenue uncertainty will be associated with lower acquisition present value, as revenue is in the gains domain. Likewise, increased operating cost uncertainty will be associated with higher acquisition present value, as costs are in the loss domain. Finally, I predict that uncertainty related to factors that are non-financial in nature will not have a significant association with the present value of the acquisition. As it is unclear whether physician preference, consumer preference, care, and research uncertainty are considered uncertain gains or uncertain losses, I predict that no significant association will exist. While these assertions are supported by the Prospect Theory literature, as was summarized by Camerer (2000), there is evidence that Prospect Theory does not hold in certain contexts (Gneezy, List, & Wu, 2006; Kalayci & Basdas, 2010). The managerial self-preservation literature would suggest that greater uncertainty should be associated with lower investment, no matter the domain of the uncertainty (Mayers & Smith, 1982; Coffee, 1986; Gupta, 1987; Chatterjee & Lubatkin, 1990; Greenwald & Stiglitz 1990; Wiseman & Gomes-Mejia, 1998).

2.5: Issues Unaddressed by the Literature

As Chapter 2 demonstrated, the economics and management literature contains several perspectives on decision making during the capital investment process. Unfortunately, the literature provides little guidance in weighing the hypothesized outcomes suggested by these theories against one another within the context of hospital equipment acquisition. This is likely the case because the theories come from different sources. Economists developed the normative literature on capital investment. Management scientists developed the behavioral theory of the firm and Bounded Rationality. Behavioral economists developed Prospect Theory. Most of the findings on capital investment in hospitals came from health services research, which is likewise a somewhat distinct academic community. This dissertation provides an empirical comparison of the hypothesized findings of these models within the context of hospitals acquiring a costly and uncertain product (Figure 4). While it is not possible for me to generally suggest that one of the theories that has been tested outperforms the others in predicting acquisition uncertainty or value, it is possible for me to provide one example of the relative performance of the various theories in predicting these outcomes.

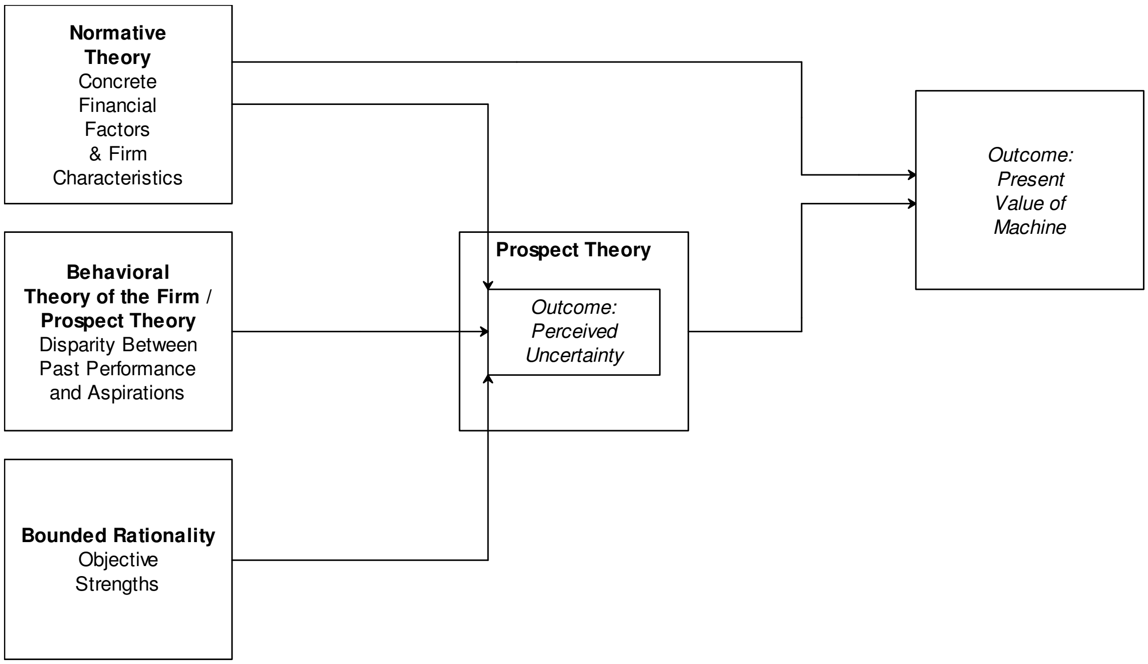

Figure 4: Potential Explanations of the Capital Investment Process

Prior to this study, there have been very few studies that have looked within firms in order to explain investment decision making. While Teplensky, Pauly, Kimberly, and Hillman (1995) examined MRI adoption using survey responses that contained some strategic measures, the firm capital investment literature has primarily relied upon accounting measures or other externally-visible proxies of performance. This study utilizes externally-visible accounting and demographic measures, as well as externally-invisible behavioral and psychological measures. As a result, it considers a far more diverse set of explanations for variation in capital investment than most of the prior literature.

Beyond its theoretical implications, this study fills a gap in the health services research literature as well. Equipment manufacturers and payers (both private and public) are interested in having a better understanding of what determines hospital capital investments in equipment. As much of the literature suggest that uncertainty plays a role in determining firm capital investments, it is likewise important to gain an understanding of what drives uncertainty.

Both CT manufacturers and payers have a vested interest in understanding the drivers behind hospital investments in CT. Manufacturers desire to increase investments, while payers likely desire to decrease investments, as CT utilization appears to grow with capacity (Baker, Atlas, & Afendulis, 2008). Due to gaps in the literature, it is unclear what approach manufacturers and payers should take when attempting to educate CT acquisition decision makers. Should they focus on changing hospitals' aspirations or objectives for their CT equipment, should they provide data that can be used to reduce uncertainty about CT performance, or should they simply do nothing? If CT investment is not dependent upon factors that may be modified through education, campaigns to influence hospitals may be wasteful altogether. This dissertation provides insights into the factors that drive the CT acquisition process. Manufacturers and payers can use the findings to better target their campaigns.

While there is great concern over the increased cancer risk to patients from more advanced CT machines, the literature does not provide clear solutions for encouraging hospitals to acquire simpler (and less expensive) CT machines that expose patients to lower doses of radiation. The problem of CT-related radiation exposure is increasing, as according to Nickoloff and Alderson (2001), "Inherent in the design of advanced CT scanners providing many new applications are elements that have the potential to increase radiation exposures to patients." This increased radiation exposure poses a serious threat. It is estimated that 500 of the 600,000 children whom receive abdominal or head CT examinations each year will eventually die of from cancer attributable to CT radiation exposure (Brenner, Elliston, Hall, & Berdon, 2001). Furthermore, it has been estimated that 150 CT-related cancers are induced for every 100,000 individuals screened with CT colonography (Berrington de González et al., 2011). By helping policymakers understand what drives hospitals to acquire more complex CT machines associated with higher acquisition costs and radiation output levels, this study contributes to the improvement of human health.

Chapter 3: Empirical Context, Data, and Methods

3.1: Empirical Context

The importance of understanding equipment purchasing is only increasing. While equipment purchasing occurs in many industries, the rapid escalation in equipment costs within the hospital industry makes studying equipment purchasing within that context particularly important. National hospital spending on equipment and infrastructure has grown from $6 billion in 1970 to $114 billion in 2008, an increase of 1,800% in less than 40 years (Hartman, Martin, Nuccio, & Catlin, 2010).

A large component of hospital equipment spending comes from the acquisition of imaging equipment. In 2005, roughly $8.1 billion was spent on purchasing imaging devices from manufacturers (Iglehart, 2007; Burns, Cisneros, Ferniany, & Singh, 2010). Computed tomography (CT) machines, the focus of this study, are very costly and have large variation in pricing. According to the ECRI Institute (2009), the cost of a new CT machine can range from $500,000 for a low-end 16-slice machine to $2,500,000 for the latest high-end machine.

The true cost of acquiring these machines is even higher when the required service contracts and building renovations are considered. As hospitals must cover their costs through their billing, these high costs have resulted in high bills. Imaging spending accounted for $3.52 billion in Medicare Part B disbursements in 2006 (GAO, 2008). Baker, Atlas, and Afendulis (2008) estimated that the addition of one CT machine to a physician's practice would have increased Medicare spending by $685,000 in 2005, and that the average amount that Medicare paid for a CT scan billed under the fee schedule was $308. On average, each additional CT machine acquired resulted in an additional 2,224 CT procedures.

Given the high expense and importance of a CT acquisition, hospitals must contemplate the decision carefully even if they have adopted similar technology in the past. While several prior studies (Teplensky, Kimberly, Hillman, & Schwartz, 1993; Teplensky, Pauly, Kimberly, & Hillman, 1995; Hillman & Schwartz, 1985; 1986) have examined the decision to adopt medical imaging devices, these technologies now have existed for around three decades, and, as a result, some of the uncertainties surrounding their operating costs, potential revenues, and clinical utility have dissipated. For the majority of hospitals, the key decision has shifted from whether to adopt CT to which specific machines to adopt. Most hospitals purchasing CTs are seeking to replace or expand their existing capacity, rather than seeking to make an initial acquisition. Thus, this study instead focuses on replacement.

3.1.1: Computed Tomography (CT) Machines

Before delving into the details of the acquisition process, it is important first both to explain CT technology, the market in which the machines are sold, and the reimbursement process. Computed tomography machines produce medical images useful during diagnosis and certain procedures. A CT image shows a slice of the human body. Multiple images can be assembled by computer software to construct three-dimensional models of structures within the body. Unlike x-rays, CT images focus on showing tissues. The technology uses radiation in the process of capturing images. While Magnetic

Resonance Imaging (MRI) also can be used to see inside the body, it is not a complete substitute for CT, as there are some situations in which CT is superior and others in which MRI is superior.

CTs are large and often need to be situated in a room of around 300 square feet. They also are energy intensive and often require new electrical lines to be run into a hospital. As a result, there are costs associated both with acquiring the machine and with situating it. While they can be leased as well as purchased, leasing does not eliminate the problem of the facility cost. The CT machines themselves often cost between $500,000 and $2,500,000, and are typically replaced within five to ten years. After replacement, they are typically resold outside of the U.S. by either the manufacturer or a refurbishing company.

3.1.2: CT Reimbursement

The complexity of the reimbursement process for CT is reflective of the overall complexity of the U.S. insurance system. When treating patients on an inpatient basis, hospitals do not receive payment for the use of CT if they are reimbursed through a Diagnosis Related Group (DRG) payment. This method of reimbursement is used by Medicare and by most major insurers. Thus, inpatient CT is a cost for the hospital, but may increase profits to the extent that its presence can attract patients with diagnoses requiring CT imaging or if the usage of CT can reduce the overall costs associated with CT. Nonetheless, a physician may still collect revenue for his or her professional services when providing treatment to inpatients that involves CT. So, inpatient CT usage generates revenues for physicians but not hospitals. In contrast, outpatient CT usage generates revenues for hospitals. The Current Procedural Terminology (CPT) code corresponding to the procedure performed is assigned to an Ambulatory Payment Classification (APC), which is then used to determine the payments to both the physician and the hospital. Hospitals may submit global charges pertaining to both physician and hospital services if they employ physicians as salaried employees (GE Healthcare, 2010). Outpatient CT usage is source of revenue for both the hospital and the physician.

Revenue growth from CT has outpaced other forms of medical spending. While the sum of all Medicare physician service payments grew by 31% from 2000 to 2005, imaging services grew by 61%, at an average rate of 10% per year. The growth rate of CTs for areas of the body other than the head exceeded the growth rate for imaging services overall. As a result of all this growth, in 2006, CT accounted for 17% of Medicare spending on imaging services (Winter & Ray, 2008).

3.1.3: CT Acquisition

CT acquisition is a complicated process wrought with uncertainty because new models arrive on the market each year. The capabilities of new models functionally differ from those of old models, as they can be used to perform new types of tests and can produce new types of software-based analysis. While acquirers may gain experience using older models of a given manufacturer or similar models of other manufacturers, this experience may be partially obsolete, as CT machines rapidly advance, but are replaced only every five to ten years.

Different manufacturers offer somewhat different software packages for their machines and their machines substantially differ in their capabilities. That is, more than an “apples-to-apples” comparison is involved. At the high-end of the market, in 2010, two different strategies were deployed. Toshiba offered a machine with one set of 320 detectors (slices), which was more detectors than was offered by any other manufacturer, while Siemens offered a dual-source machine, which was able to capture images with two sets of detectors at once. The significant difference between these two technologies added to the complexity of the decision making process. In addition to differing in their number of slices and sources, CTs differ in their bore size (influencing their ability to handle obese and claustrophobic patients), software platforms, and cost. Due to the cost and complexity of the acquisition process, acquisition of a CT machine is a substantial decision for a hospital which almost always requires managerial approval.

While different hospitals delegate ultimate purchasing authority to different individuals (typically the chair of the department of radiology or an equipment purchasing manager), in most cases the financial impact of the acquisition is considered substantial enough that it must be evaluated by a group of individuals including the CFO. Although the clinical staff may be less directly involved in the process, they often spend substantial time describing their desires to key decision makers (such as the chair of the department or the purchasing administrator), as they are the end users. The purchasing process takes a substantial amount of time on the part of the decision makers and staff. It often involves consensus building, negotiation, and research.[1] While the purchasing process described in this dissertation is specific to one industry, the phases described are remarkably similar to the buying decision phases that Lilien and Wong (1984) described for the metalworking industry: initiating the purchase, determining the type of product to

[1] This description of the acquisition process was constructed using information obtained during nine qualitative interviews with decision makers from eight healthcare systems.

be purchased, drawing specifications for the product, evaluating suppliers, selecting suppliers, determining the cost, and giving final authorization for the purchase. Illuminating somewhat similar processes, Bower (1970) and Bromiley (1986) examined the resource allocation and purchasing process at a multiple firms using qualitative means.

The purchasing decision process is at first driven by the existence of a desire to fulfill one or more objectives. Hospitals have a variety of objectives which can be broadly categorized as revenue maximization, cost reduction, care improvement, satisfaction of physician and consumer preferences, and research maximization (Long, 1964; Reder, 1965; Ginsberg, 1970; Feldstein, 1971; Newhouse, 1970; Lee, 1971; Pauly and Redisch, 1973; Burns, Shah, Sloan, & Powell, 2009). Different hospitals have different priorities and hold these objectives to differing degrees. Either the clinical staff or the marketing department presents a desire to the acquirer. The desire for new equipment may result from a technological advance, an acquisition by a competitor, an increase in demand resulting from new clinical applications, or the obsolescence of an existing piece of equipment.

After a general desire for new equipment is identified, the desire must be further fleshed out through the creation of a list of equipment requirements. In some hospitals, the purchasing manager formally organizes a group of users and guides them in creating a requirements document.[2] In other hospitals, the chair of the department of radiology

[2] CT and MRI machines are very large and expensive. Thus, when multiple departments within a hospital wish to utilize their output, they may jointly discuss the purchasing decision. Even if a scan is not ultimately read by the Department of Radiology, it usually makes little sense for other departments to operate machines entirely separately from the Department of Radiology. Nonetheless, on occasion, departments do operate machines separately. As this is a substantial decision, the Department of Radiology is usually aware when this occurs.

mentally creates a requirements document using a less formal process based on his or her observations and interactions with the clinical staff. While understanding the desires of the hospital, the acquirer must keep in mind that a business case must be developed to justify the acquisition. This business case will include both the cost of the acquisition, as well as all the potential benefits it may bring. However, not every acquisition increases profit in and of itself; during interviews, purchasers have recalled unprofitable acquisitions done for other motives, such as maintaining or increasing the quality or quantity of care, or retaining key personnel. If the acquisition of a CT machine can attract physicians or patients likely to generate large revenues, it may be very well worthwhile, even if the machine in isolation is not profitable. This may be the case if the machine is primarily used for inpatients covered by the Diagnosis Related Group (DRG) system, as the DRG system does not provide hospitals with reimbursement for CT utilization.

Once equipment requirements have been identified, the acquirer then typically gathers more information about the various available CT machines, such as their operating and maintenance costs, utility in performing different types of imaging studies, and image quality. This may be done through communicating with peer institutions, reading vendor literature, and examining information provided by trade associations and buying groups. Field research indicated that vendors sometimes bar institutions receiving substantial discounts from disclosing their prices to peers or to companies determining industry averages (Aunt Minnie, ECRI, etc.). As a result, the comparator prices seen during the research phase are likely on average slightly higher than the true average price.

After determining the machines that are likely to discuss the hospital’s desires and creating an estimate of the price range of the machines that they would like to consider, the acquirer typically must present a business case for the acquisition to the CFO. The CFO will then assess the hospital's budget and determine the best investments for the hospital to finance that year. Money can come from profit accumulated in the current or prior years, through the issue of a bond, through donations, or in the case of for-profit hospitals, through the sale of equity. Provided that the acquirer has received funding from the CFO, he will then work to get the best price for the machine. Sometimes, acquirers will strategically request quotations for products that do not strictly meet their desires to gain additional leverage when negotiating. Some vendors may be viewed more favorably than others, either as a result of prior experiences or as a result of prior acquisitions. As each vendor has its own flavor of the DICOM imaging standard, only partial inter-compatibility between the equipment of different vendors exists.[3] Therefore, when negotiating with vendors, the acquirer must weigh price against issues such as equipment quality and equipment compatibility with pre-existing equipment.

Although finalizing requirements and negotiating both the hardware and service elements of the acquisition contract takes time, the acquirer must consummate the deal within the timeframe for which the money has been allocated by the CFO, which normally is one fiscal year. While technology is always advancing and there are always benefits to waiting for the next model, the acquisition must be made within the specified timeframe, or else the acquirer faces the possibility that the CFO may reallocate the allotment of capital to another investment. In addition to preventing the acquirer from waiting for technological improvements, this constraint limits the ability of the acquirer

[3] Digital Imaging and Communications in Medicine (DICOM) is a standard for storing and viewing medical images, such as CT scans. CT machines produce DICOM images and often come with software to read them. However, slight differences in the DICOM output of different manufacturers makes interoperability difficult.

to search for options after receiving a commitment of capital. Thus, the behavior of the acquirer may be boundedly rational due to the limited availability of search time. It is impossible for the acquirer to wait indefinitely for there to be less uncertainty or better technology (Simon, 1947).

As a result of the variation in the hardware, software, operating costs, and fixed costs of CT machines, the benefits and drawbacks of each piece of equipment are slightly different. Thus, the acquirer must make trade-offs when making a purchasing decision as different machines offer different combinations of attributes. He furthermore may experience some imprecisely quantifiable uncertainty over the outcomes that he is likely to experience as a result of purchasing the equipment.

CT Machines as a Rich Case for Study

While there are many non-commodity technologies whose acquisition is fraught with uncertainty, this study focuses on one type of medical imaging equipment—CT. CT machines are durable, with many hospitals retaining them for between five and fifteen years. They are also rather expensive and in many hospitals are among the largest equipment acquisitions in the budget. As a result, a substantial degree of thought must go into determining which machines should be acquired and into justifying purchasing decisions. The machines are highly complex and vary along multiple attributes, such as financial, medical, and research potential. Hospitals often hold multiple objectives for the machines which correspond to each of these attributes. Furthermore, they are somewhat of an experience good, in that hospitals may have reduced uncertainty about the capabilities and performance of a machine if they have previously owned a similar machine from the same manufacturer. It is often impossible for a hospital and its staff to fully understand the benefits and drawbacks of a particular machine until it has been owned for some time. (To partially mitigate this, some acquirers request onsite demonstrations at other hospitals.) While it is possible to lease machines, the difficulty of situating a CT machine makes it difficult for hospitals to rent and test machines. Only 39 of the 221 respondents reported that their hospitals had used a mobile CT. As mobile CT has both higher fixed and operating costs than fixed CT, it was not widely used within the sample (Reeve & Baladi, 1995). As the machines advance, subsequent acquisitions are likely to be made from a different choice set than prior acquisitions. Thus, prior acquisitions provide only partial information that can be used to reduce the uncertainty of future acquisitions.

There are often substantial trade-offs between different models of CT machines. Between machines, there is variation in the image resolution, speed of image acquisition, cost of machine acquisition, and operating costs. Furthermore, different machines have different form factors. Within the Siemens CT product line, the machine with the highest resale value is worth over four times as much as the machine with the lowest resale value. The machines each have slightly different features and there is no machine that is dominant and most suitable for all hospitals. The market is divided between four major manufacturers whom each produce a handful of models. Thus, when determining which machine to acquire, a hospital must decide the nature of the capabilities it desires (i.e. low maintenance costs, novel features to be used in research, etc.) which will then drive its preference for manufacturer and model.[4]

[4] While all of the current machines are more or less adequate for meeting clinical needs, more advanced machines may be needed to meet marketing or research needs.

Although this study exclusively focuses on one medical imaging technology, there are many technologies in other industries that share the attributes of being multi-faceted, durable, differentiated goods that undergo technological progress. Airlines face similar issues when considering which aircraft to acquire or lease for their fleets (McCabe, 1987). Purchasing decisions must be made under uncertainty in the plastics, container, and food industries (Lawrence & Lorsch, 1967). Similar scenarios also likely occur in companies purchasing technology-intensive manufacturing equipment. Decisions involving uncertainty even occur in the context of industrial firms making repeated purchases of raw materials that they use as inputs (Puto, Patton, & King, 1985). The hospital context is ideal for operationalizing this study, as there are numerous hospitals, many of which have decided to adopt CT technology. The substantial degree of variation in the nation's hospitals makes it possible to survey hospitals with wide variation in both reported objectives and uncertainties.

3.2: The Data Collection Process

As no suitable database pertaining to firm acquisitions existed, exploring the hypotheses of this study required the creation of a novel dataset. This dataset was created through a three-phased process. First, qualitative interviews were conducted to determine the relevant issues and constructs. The findings from these interviews were used to construct a survey which was then distributed in a pilot study. After examining both the completeness and nature of the responses, the survey was refined and conducted on a broader scale. It is the data from this second survey which is used to explore the topics of this dissertation. Since this data source requires substantial discussion due to its novelty, this chapter explores its features, merits, and flaws.

3.2.1: Qualitative Data

To determine the nature of the objectives and uncertainties that hospitals have surrounding their CT machines, I conducted a series of nine qualitative interviews with decision makers from eight different health systems. To do this, I used a case study process loosely similar to the one proposed by Eisenhardt (1989). My case study process differed in that its purpose was not to derive answers in and of itself, but instead to prompt questions for future quantitative exploration. Each interview was approximately an hour long. During the interviews, I asked the respondents about how their hospitals acquired CT machines. I additionally asked the respondents about how they chose to adopt or disengage from medical imaging technologies. In selecting respondents, I attempted to include a broad variety of perspectives. All of the healthcare systems in the Philadelphia area were contacted, although not all ultimately agreed to participate. Additional healthcare systems in the Chicago area were also contacted. The sample included top academic medical centers, regionally-focused academic medical centers, a children's hospital, and a community hospital. From these interviews, I determined that hospitals primarily consider six general attributes when purchasing CT machines: revenue, operating costs, ability to meet physician preferences, ability to meet consumer preferences, ability to deliver high-quality care, and suitability for research. All of the machine attributes mentioned during the interviews were grouped into these categories through a process loosely based off of grounded theory (Corbin & Strauss, 1990). It has been suggested that hospitals may maintain multiple missions simultaneously, some of them other than profit maximization (Walston, Kimberly, & Burns, 2001). While there are obviously other attributes that hospitals consider when purchasing machines, by and large, they can be simplified into a combination of these six. Revenues and costs were measured separately because they are derived from separate sources and have very different sets of uncertainties associated with them. The manufacturer plays a key role in determining a machine's operating costs and the variance in those costs, while insurers and the government influence revenues. These differences make it important to keep the two distinct.

After speaking with the radiologists about several imaging modalities, I decided to focus the study solely on the acquisition of CT machines. While CT machines are part of a portfolio of technologies that includes MRI and PET/CT, I felt it was best to only focus on one such technology in order be sure that apples-to-apples comparisons could be made. In the interest of keeping the survey brief, I did not ask about the other modalities present at the hospitals. McNamara and Bromiley (1997) found that bankers framed risks narrowly, rather than as members of larger classes. It is quite possible that physicians and hospital administrators similarly frame the acquisition of a CT machine as an individual investment made under uncertainty, rather than as part of a portfolio of uncertainties. Given that qualitative interviews have shown that CT acquisitions typically occur one at a time and are not bundled with other acquisitions, it is very possible that this is the case.

3.2.2: Quantitative Data

Table 1 contains data from the 2008 AHA survey on the national prevalence of CT machines. As can be seen, nearly 83% of American hospitals have at least one CT machine. However, only 32% of hospitals in the study had an advanced CT with 64 or more slices.

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Insert Table 1 about here

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The 2008 AHA survey further revealed that the majority of hospitals are not for-profits. Out of the 6,407 hospitals that reported the nature of their control to the surveyors, only 1,595 were classified as for-profit. The vast majority of the hospitals in the dataset are owned by non-Federal government (1,429), owned by the Federal government (216), or owned by a non-government non-profit institution such as a church (3,167). The relative lack of for-profit hospitals poses a challenge, which can be reduced through focusing the study on Texas, a state that is relatively rich in for-profit hospitals.

The data used in this study were collected both through surveys sent in the mail and at the Radiological Society of North America (RSNA) 2010 Annual Meeting. Additional data were collected through a web-based survey. However, as web-based data collection was less fruitful than mail-based collection, more resources were devoted to mail-based collection.

3.2.3: Survey Design

When surveying through the mail, I distributed copies of the survey along with a self-addressed, stamped envelope, as such a design has been shown to increase response rates by 2-4% (Dillman, 1978; Dillman & Moore, 1983; Dillman, 1991; Armstrong & Lusk, 1987). For similar reasons, commemorative stamps were used on the envelopes (Armstrong & Lusk, 1987). The survey was accompanied by a brief and professional cover letter which deliberately mentioned university sponsorship and was not personalized (Simon, 1967; Andreasen, 1970; Jones & Linda, 1978; Mangione, 1998). The survey itself was only three pages long, as surveys longer than four pages have lower response rates (Yammarino, Skinner, & Childers, 1991). For the same reason, it was printed letter-sized paper (Jansen, 1985). While it was not possible to measure each construct using multiple items due to this length limitation, keeping the survey short boosted the response rate. A pilot study with a more detailed survey was conducted at RSNA 2009, and received only 43 usable responses, compared to the 82 usable responses collected using the shortened and revised survey at RSNA 2010. Both the pilot and final surveys were administered at the same booth at RSNA, over the same period of time.

Each survey was marked with a unique identifier that was linked to the name and address of the recipient. It was necessary to make the survey confidential but not anonymous, as respondent identifiers were used to link respondents with the AHA Survey Database. Non-responders were sent a second copy of the survey several weeks later. Furthermore, the identities of respondents were noted and respondents were asked to send additional surveys to their peers. It has been shown that confidential surveys do not get significantly fewer responses than anonymous surveys. Furthermore, privacy concerns are unlikely to have dissuaded many people from responding, as the questions on the surveys are not on topics about which people are likely to have privacy concerns. The survey items concern vague notions whose disclosure is unlikely to endanger the respondent or the respondent's firm.

To encourage people to respond, I enclosed a letter offering two incentives. I rewarded rapid response by offering a prize (an Amazon Kindle valued at $139) to the fiftieth respondent. Furthermore, I incentivized later responders by offering a group jackpot for a high response rate. I offered to donate $500 to Doctors Without Borders if 50% of surveyed individuals responded, and framed non-response as having the potential to let the charity down. By doing this, I was able to tie a larger financial consequence to the individual behavior of respondents. I offered items via a lottery as Goritz (2004) demonstrated that offering items via lottery does not result in significantly worse response quality or quantity than offering items to each respondent. However, offering items via lottery has substantially lower costs, as the cost of the incentive per respondent declines with the number of respondents rather than rising.

3.2.4: Response Rates

In order to get a geographically-concentrated sample of radiologists with multiple respondents employed at the same hospital, I surveyed 958 (1,000 envelopes were sent; 42 were ineligible due to relocation or self-declared ineligibility) Texas-based radiologists using contact information provided by the Texas Medical Board. By sending a survey to nearly every hospital-based Texas radiologist conducting diagnostic imaging, I ensured that the population I surveyed was representative of the Texas population. Two waves of the survey were sent, and ultimately 47 radiologists responded; a response rate of 4.9%. In order to get a sample of administrators (rather than clinicians), I surveyed 480 (491 envelopes were initially sent; 11 were ineligible due to relocation or self-declared ineligibility) individuals using a mailing list from the American College of Healthcare Executives (ACHE). I received 65 responses after two waves, for a response rate of 13.5%. To better triangulate my results, I sent 83 respondents from the ACHE and Texas populations a packet containing two additional surveys for their colleagues to complete. These colleague responses contributed 22 surveys to the sample.

I made an attempt to gather data via a web-based survey with comparable questions to the paper-based version. I hired a medical marketing firm to distribute the survey to a proprietary list of 4,107 radiologists. After only 4 radiologists responded to the initial wave, a response rate of 0.097%, I decided to pursue a solely paper-based approach instead. The low response rate from the web-based survey may be due to several factors. First, the e-mails sent by the marketing company may have been perceived as spam by recipients or their e-mail servers. Second, the web-based version of the survey may have taken longer to complete than the paper-based version of the survey. Finally, due to the proprietary nature of the mailing list, I had less control over the characteristics of the included individuals than was the case with the Texas and ACHE lists. As a result, it may have contained more individuals for whom the survey was not applicable.

There is evidence that web-based surveys have lower response rates than mail-based surveys. Kaplowitz, Hadlock, and Levine (2004) found that within a University population, the response rate from a mail-based survey was 52% greater than the response rate from a web-based survey. As the population that they studied consisted largely of students whom were active computer users, the discrepancy may be less pronounced than would be the case for a somewhat older and less homogeneous population of radiologists.

While it is not possible to tell how the respondents who answered the survey differed from typical radiologists, hospital executives, and medical administrators, there is information on the trends in the general non-response biases in physician surveys. Deehan et al. (1997) reported that among British General Practitioners (GPs), response rates in the first two waves of a mail survey were lower for older GPs. Male GPs were less likely to respond than female GPs. Using the same dataset, Templeton et al. (1997) reported younger GPs were more likely to respond to both mail and telephone surveys than older GPs.

These findings were supported by analyzing the tenure of the respondents. For the two data sources with two waves (ACHE and Texas), the respondents who replied to the second wave had an average of six years greater tenure than the respondents who replied to the first wave (16 years versus 10 years). More recalcitrant second wave responders may be more representative of the general population than the more eager responders who replied to the first wave. Thus, the bias found by Deehan et al. (1997) appears to have been present here as well.

Only the ACHE and Texas samples could be divided into two waves. I performed a series of Mann-Whitney U tests to determine whether there were systematic differences between the early and late responders. I found that no significant differences existed for most of the variables. However, there were a few variables for which the difference was significant ($p<.05$). While only 4% of Wave 1 responders were from for-profit hospitals, 30% of Wave 2 responders were from for-profit hospitals. Likewise, 51% of Wave 1 responders were hospital system members, while 73% of Wave 2 responders came from hospitals which belonged to systems. Catholic status also differed; 12% of Wave 1 responders came from Catholic hospitals, while 30% of Wave 2 responders came from Catholic hospitals. While the majority of the measures on the survey were not significantly different for either of the waves, the Wave 2 responders reported higher financial uncertainty than the Wave 1 responders (a factor mean of 3.07 versus 2.58).

I also conducted tests to determine whether there were fundamental differences in the values reported in the different samples. The populations of respondents were a bit different in each of the samples; the Texas sample contained responses from Texas-based radiologists; the ACHE sample contained responses from hospital administrators that belonged to ACHE, and the RSNA sample contained a mix of individuals with the resources to attend RSNA. One-way ANOVA suggested that there was only significant between-source variation on the variables related to for-profit status, Critical Access Hospital status, membership in a hospital system, total facility expenses, total full-time equivalent employees, use of an administrator as a key decision maker, perceived financial factor uncertainty, perceived revenue uncertainty, perceived cost uncertainty, and the strength with which the financial factor was held. The means for each of these variables in the different samples is provided in Table 20.

Insert Table 20 about here

The Texas subsample had less selection bias, as all relevant Texas hospitals received at least one copy of the survey. However, Texas hospitals differ in several fundamental ways from other hospitals in the country. The fact that Texas hospitals are more likely to be for-profit was a motive for choosing Texas for intensive study in the first place. Unsurprisingly, Mann-Whitney U tests revealed that the Texas responses differed from the rest of the sample on their likelihood of being from for-profit hospitals. They also differed in system membership, financial factor uncertainty, cost uncertainty, the number of payer contracts, and total facility expenses as well. The greater propensity of the Texas respondents to come from for-profit hospitals may have driven the other observed differences as well. A Mann-Whitney U test of the entire sample revealed that for-profit hospitals have significantly greater perceived financial factor uncertainty than other hospitals.

To account for all of these differences, I incorporated variables indicating the source of the data into my models. A series of dummy variables were used to account for any differences between the ACHE, Texas, and other sources, when compared to the baseline source. I supplemented the mail-based and web-based survey data with in-person surveys conducted at the 2010 Annual Meeting of the Radiological Society of North America (RSNA). This was used as a baseline, in that it contained a broad national sample of hospitals, and contained respondents with a variety of backgrounds. RSNA was attended by radiologists, radiological technicians, medical physicists, and hospital administrators. As a result, RSNA enabled me to diversify my sample through surveying a broader range of individuals. Over 60,000 people were in attendance (RSNA, 2010). I stood in a booth on the tradeshow floor and asked every passerby who was a member of the organization or involved in sciences associated with radiology, “Do you deal with CT?” If the person responded in the affirmative, I then proceeded to ask, “Do you have any involvement in the CT purchasing decisions of a hospital?” If I received an affirmative response, I then proceeded to ask whether they would be willing to fill out a survey. Respondents were compensated with an item of minimal value (gourmet chocolate bar worth $3). Only respondents employed in hospitals based in the United States were included in the sample, which contained 82 responses.

There may have been a number of factors at play driving the low response rate. To respond, the recipient had to: be employed at a hospital with a CT, have been employed at the time at which the machine was acquired, and have been involved enough in the acquisition process to feel comfortable answering the questions. Only 6% of respondents reported that their confidence in the accuracy of their responses to the survey was less than ‘4’ out of ‘7’. As it is unlikely that 94% of the people whom received the surveys were involved in the CT acquisition process, many of the less confident recipients may have been non-responders. To illustrate this point, only 3% of the ACHE and 2% of the Texas survey respondents had a confidence level of below ‘4’ out of ‘7’. Meanwhile, 9% of the RSNA survey respondents had a confidence level below ‘4’ out of ‘7’. The RSNA respondents had the pressure of the presence of the experimenter that the mail-based respondents did not experience. Furthermore, many of the RSNA attendees offered the survey refused to take it due to their lack of involvement in the CT acquisition process.

3.2.5: Survey Issues

While conducting the survey for this research, feasibility must be balanced with validity. Access to key decision makers is a scarce commodity as these individuals tend to be both highly busy and highly compensated. As such, the survey must do its best to accurately describe a hospital's decision making process in as few questions as possible.

The three major forms of biases that this survey presents are common method bias, retrospective recall bias, and sole source bias. In short, the dependent and independent variables may be somewhat correlated simply because they are obtained from the same form and provided by one individual in one sitting. As some of the questions ask about past perceptions and decisions, retrospective recall may be an issue. Likewise, the use of a single respondent introduces sole source bias, as the responses of the respondent may not be representative of the organization.

Before attempting to remedy common method bias, it is important to consider whether it is even an issue. It has been argued that common method bias (monomethod bias) is not as great a problem as it has been claimed (Spector, 2006). In fact, the bias may serve to blunt the significance of findings, rather than increase them. Nonetheless, some measures can be taken to reduce issues related to the use of a common method. It has been suggested that increasing the length of the scale can reduce this bias, as people have more difficulty remembering their prior responses if they made them on a scale with more options (Harrison, McLaughlin, & Coalter, 1996; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

This finding on the influence of additional items on common method bias was part of the motivation to use a 7-point Likert scale, rather than the traditional 5-point design, as was used in the pilot study. Furthermore 7-point Likert scales were used because Cox (1980) found that scales with seven items, plus or minus two, most effectively transmit information. Cox further suggested that scales with an odd number of response alternatives be used if it is possible to have a neutral response. Concurring with Cox, Matell and Jacoby (1971) found that when asked theoretical questions, subjects had the most test-retest reliability for 8-point Likert scales, and the second most test-retest reliability for 7-point scales.

Retrospective surveys, such as this one, may result in inaccurate responses. Nonetheless, they are a viable research methodology if used carefully (Miller, Cardinal, & Glick, 1997). Huber and Power (1985) noted that people tend to provide inaccurate information for one of four reasons; they are motivated to do it, they inadvertently do it due to perceptual or cognitive errors, they lack information related to the question asked, or they have been subjected to an inappropriate data elicitation procedure. The second and third reasons could potentially be a result of the decision having occurred in the past. To reduce errors related to the first, I have made the survey confidential, and have only identified respondents and hospitals through the use of a secret serial number. To reduce the second and third types of error, Huber and Power recommend minimizing time between the event in question and the collection of data. By focusing on the most valuable CT machine, which is likely to be the machine most recently acquired, this study reduces this bias.

Free reporting has been shown to reduce errors in retrospective reporting (Miller, Cardinal, & Glick, 1997). Although it is not possible to use free recall entirely for this instrument, it is possible to anchor the respondents' answers on their recollections before having them provide answers to Likert scale questions. This survey promotes self-anchoring by providing respondents a brief free response area to explain their motives for acquiring a CT before having them complete Likert scales.

It has been claimed that using a sole reporter, such as the CEO, is not an accurate means of assessing corporate strategy (Bowman & Ambrosini, 1997). Furthermore, it has been shown that better predictions of buying behavior within group buying decisions can be made if multiple informants are used (Wilson and Lilien, 1992). While it is not preferable to use a sole source, when it is necessary, Huber & Power (1985) recommend identifying and surveying the person with the most knowledge of the issue of interest.

When possible, multiple informants from individual hospitals have been used. Comparing the responses of multiple informants makes it possible to assess the accuracy with which respondents have recalled information. Triangulating findings reduces same-source bias. This triangulation was done both through mailing and e-mailing additional survey forms for respondents to give to their colleagues and through encouraging colleague groups encountered at RSNA to have all members complete the survey. Ultimately, the sample consisted of 145 hospitals with a single informant, 22 hospitals with two informants, 8 hospitals with three informants, and 2 hospitals with four informants. Thus, there are multiple informants for 32 of the hospitals in the sample. If the sample is restricted to only contain respondents whom were both employed at their hospital in the year prior to the acquisition of the current most valuable CT and who rated their confidence as their responses as 4 or greater on a 7-point Likert scale, the sample consisted of 126 hospitals with a single informant, 13 hospitals with two informants, 5 hospitals with three informants, and 2 hospitals with four informants. Under these restrictions, there are multiple informants for 20 of the hospitals in the sample.

In order to determine the reliability of the variables, I used the reliability of the within-group means computed using one-way ANOVA. One-way ANOVA produces measures of both between and within group variation, which can then be used to determine reliability by dividing the difference of the between mean squared variance and the within mean squared variance by the between mean squared variance (Leoutsakos, 2006). The estimated reliability of a mean is a number between 0 and 1, with 0 indicating complete within group disagreement and 1 indicating complete within group agreement. Reliability ranging from 0.41 to 0.60 is considered fair, while reliability from 0.61 to 0.80 is considered moderate, and 0.81 and above is considered substantial (Landis & Koch, 1977; Shrout, 1998). Table 2 contains the within-group reliability measures for the variables on the survey.

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Insert Table 2 about here

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Analyzing the reliability of the variables produced a number of findings. First, the reliability of responses concerning the current most valuable CT is greater than the reliability of the responses concerning the prior most valuable CT. This makes sense, as not all of the respondents were employed at their respective hospitals at the time of the purchase of the prior most valuable CT. Furthermore, the details of the machine may be a more distant memory. There was somewhat stronger disagreement on the extent to which hospitals held minimizing operating costs and maximizing the quality of care as objectives. Likewise, there was substantial disagreement on the extent to which operating costs were being minimized before the acquisition of the most valuable CT. Furthermore, there was substantial disagreement on the extent to which hospitals experienced uncertainty over the revenues and operating costs associated with the most valuable CT before acquisition. There was also disagreement over whether the key decision maker was an administrator or clinician.

Although the retrospective analysis conducted in this study may distort the findings and introduce problems with recall, it also has advantages. Fischer, Carmon, Ariely, and Zauberman (1999) found that the preferences that individuals construct can depend on the task goal of the construction process. When respondents are asked about objectives constructed in the past, this is less likely to be an issue, as no new objective construction is required. If the respondent was at all involved in the purchasing process, it is likely that he or she constructed or received the hospital's purchasing objectives before the purchase was made. Thus, the responses are less likely to be sensitive to method of inquiry or problems arising from the priming of objectives (Van Osselaer et al., 2005). Nonetheless, it has been shown that when goals are attained, they become more attractive when retrospectively ranked among goals, and when they are not attained, they become less attractive (Filer, 1952). If Filer's finding holds in this setting, then a relationship will exist between the retrospective ratings of the objectives and the extents to which they were ultimately achieved.

Another issue introduced by the use of a retrospective analysis is variation in the timing of acquisition. As CT machines are durable goods, hospitals do not buy new machines every year. Thus, when acquirers are surveyed, they respond in the present, which may be several years after the relevant equipment has been acquired. The passage of time is likely to reduce uncertainty about technological acquisitions, not increase it. This issue will likely reduce the strength of the relationship between uncertainty and goals by in general reducing the level of uncertainty reported by hospitals that have owned the machines longer. The problem posed by this is not likely to be high, as 60% of overall responses, and 65% of responses by people employed at the time of acquisition and with certainty of their response greater than or equal to 4 out of 7, reported that their most valuable machine had been purchased in the last three years.

Selection Bias

Another major concern that may be had about the dataset is that the hospitals that responded to the survey are somehow fundamentally different than the average American hospital with a CT machine. For one, the hospitals in the sample are far more likely to be based in Texas, as Texas radiologists were intensely sampled in order to get more for-profit hospitals in the sample. The sample included 177 different hospitals, of which 173 could be matched to hospitals in the 2008 American Hospital Association Annual (AHA) Survey Database. I used the Mann-Whitney U test to determine whether the responding hospitals differed from the rest of the population on a number of characteristics. I chose the Mann-Whitney U test over Student's t-test because it is more robust to outliers and does not require the assumption that the data be normally-distributed. The means for several characteristics of these hospitals differed from other hospitals in the overall population on the following:

- Number of HMO contracts (p=.0187; 12.7 in sample vs. 9.2 out of sample)
- Number of PPO contracts (p=.0000; 27.0 in sample vs. 19.3 out of sample)
- Number of hospital beds set up and staffed (p=.0000; 281 in sample vs. 129 out of sample)

- Number of hospital Medicaid days (p=.0033; 290 in sample vs. 357 out of sample),
- Total facility expenses excluding bad debt (p=.0000; 350,000,000 in sample vs. 136,000,000 out of sample)
- Average daily census (p=.0000; 253 in sample vs. 112 out of sample)
- Number of FTE personnel (p=.0000; 2440 in sample vs. 980 out of sample)
- Number of FTE radiology technicians (p=.0000; 62.4 in sample vs. 26.9 out of sample)
- Number of FTE physicians and dentists (p=.0000; 80.5 in sample vs. 21.8 out of sample)
- Whether facility is a critical access hospital (p=.0000; 6% in sample vs. 26% out of sample)
- Whether facility is a rural referral center (p=.0415; 11% in sample vs. 7% out of sample)
- Whether facility is Catholic Church operated (p=.0944; 17% in sample vs. 13% out of sample)

However, the hospitals did not differ significantly (p<.05) on the following:

- Percentage of the hospital's revenue paid on a capitated basis
- Percentage of the hospital's revenue paid on a shared risk basis
- Number of hospital admissions
- Number of hospital Medicare days
- Hospital payroll expenses
- Hospital total expenses, including bad debt
- Property, plant, and equipment, at cost
- Accumulated depreciation
- Total capital expenditures
- Whether facility is a community hospital
- Whether facility is the sole community provider

The results of the Mann-Whitney U tests suggest that the respondents to the survey came from hospitals with stronger managed care relationships and larger facilities (more beds and personnel). As all of the hospitals from the Texas sample were Rural Referral Centers, it is not surprising that Rural Referral Centers are overrepresented in the overall sample. Although every hospital in both the in sample and out of sample populations had either purchased or leased a CT machine, the in sample hospitals may have had the scale and financial resources to have done so more recently. The AHA Survey Database does not provide information that can be used to determine how recently a CT acquisition has occurred.

3.2.6: The American Hospital Association Annual Survey Database

2008 American Hospital Association Annual Survey Variables

Using the respondent's hospital's name, and in cases of ambiguity, the address as well, hospitals mentioned in the survey were paired with hospitals in the 2008 American Hospital Association (AHA) Annual Survey database. Doing this had two advantages. First, it enabled the creation of a briefer survey instrument, increasing the likelihood of response. Second, it likely increased the accuracy of the responses. It is somewhat unlikely that radiologists and radiology administrators have a precise understanding of the financial performance of their hospitals and the nature of their hospitals' managed care contracts. The American Hospital Association had both the authority and budget to ensure that this sort of data was collected precisely.

While the AHA Database contains several measures related to costs, it does not contain any measures related to revenue, profitability, or any other measure of overall financial performance. Likewise, no measures of uninvested capital are reported. Although the survey instrument used by the AHA asks hospitals to report their revenue, the AHA has an agreement with respondents that this information will not be disclosed to the public. This is unfortunate, as it forces this study to use self-reported assessments of financial performance. Furthermore, as these measures are not precisely available, it is not possible for any part of this study to consider the influence of slack resources.

3.3: Variables

The survey discussed in this section is provided in its entirety in the appendix. The purpose of this section is to describe the definitions of all of the variables on the survey, the definitions of all variables derived from survey, and the definitions of the variables incorporated from the American Hospital Association 2008 Annual Survey.

Crum and Derkinderen (1981) stated that the literature on multiple-objective decision making suggests that the maximum number of goal variables that can be handled by a decision maker ranges between five and nine. Keeping this in mind, this study focuses on six objectives for CT acquisition that are likely to be relevant to most hospitals: maximizing revenue, minimizing operating costs, satisfying physician preferences, satisfying consumer preferences, providing high-quality patient care, and performing novel research. While only the research objective is not directly or indirectly tied to profit maximization, different strategies for profit maximization can be employed. For instance, some hospitals might employ a high-volume strategy with low margins, while others might employ a high-margin strategy that results in lower volumes. As a result, it is possible for there to be diversity in the importance placed on the objectives in question, even if all of the hospitals are profit-maximizing. To capture this, the independent variables on the survey instrument focused on these six attributes, but asked about them in a variety of different ways. Each of these attributes is considered separately, as there is evidence that multiple uncertainties should be modeled separately, rather than as a single construct (Miller & Bromiley, 1990; Wiseman & Catanach, 1997).

3.3.1: Dependent Variables

There are two sets of dependent variables used in this study. The first are several measures of uncertainty about the most valuable CT machine at the time of acquisition. These dependent variables are used in the analyses of Hypotheses 1-3, which examine the determinants of a hospital's pre-purchase uncertainties about its most valuable CT machine. Hypotheses 4 and 5 are tested with a single dependent variable; the present value of the most valuable CT machine.

Pre-purchase uncertainty. To determine the level of uncertainty the hospital faced before acquiring its most valuable CT system, respondents were given 7-point Likert scales for each of the objectives, and prompted to answer, "Before your hospital obtained its most valuable CT system, how certain was your radiology department's leadership of the CT's ability to meet the following objectives?" A rating of '1' corresponded to "Very uncertain", while a rating of '7' corresponded to "Very certain." After providing the ratings, respondents were asked, "How well do you feel you recalled these uncertainties?" Again, they were provided a 7-point Likert scale. This time, a rating of '1' corresponded to "Very poorly" and a rating of '7' corresponded to "Very well".

In the models for which uncertainty is treated as a dependent variable, revenue and cost uncertainty have been merged into a factor called "Financial Uncertainty", weighted by the weightings calculated by Exploratory Factor Analysis. Likewise, physician preference, consumer preference, and care uncertainty have been merged into a factor called "Customer Desires" uncertainty. Exploratory Factor Analysis suggested that research uncertainty was not part of either factor. In the models in which uncertainty is used as a predictor of the present value of the acquisition, the uncertainties were not grouped into factors so that a comparison of revenue and cost uncertainty is possible.

Present value of the most valuable CT. The outcome examined by Hypotheses 4 and 5, which explore the determinants of the value of the hospital's investment, is the present value of the hospital's most valuable CT machine. As purchasing agreements are often confidential, it will not be possible to obtain the actual amount of money spent on equipment. Furthermore, due to depreciation, the acquisition prices of equipment are unlikely to be reflective of their contemporary value. Thus, the CT machines were instead valued at their common fair market value. Just as the Kelley Blue Book can be used to determine a rough price for a particular make of car, the pricing information on ECRI can be used to determine the rough value of imaging equipment. The prices being compared were all determined simultaneously, and thus account for changes that have occurred due to depreciation.

Rather than examining the most recent acquisition, the most valuable piece of equipment owned was used as a measure of the most advanced investment. It is quite possible that the most recent imaging equipment acquisition is that of a "workhorse" machine, of limited technical sophistication, but of great clinical value. Workhorses built according to less advanced designs command lower prices than the latest and greatest machines. Fair market value allows all machines to be compared, and discounts advanced older machines over time. One issue that may arise is that some hospitals may have acquired a given model later than others, and as a result, were able to make the acquisition at a lower price. In order to control for this, the number of years that have elapsed since the acquisition of the most valuable machine was included as a control in the model. (The year of acquisition was reported by respondents on the survey.)

3.3.2: Independent Variables

While the three models examining the determinants of uncertainty and the two models examining the determinants of acquisition value each share the same dependent and control variables, each model utilizes different independent variables. While most of the models use the same types of independent variables for all the different CT attributes, the normative models for revenue and cost use substantially different independent variables.

Normative Models

Both the normative models testing the influence of economic factors on uncertainty (Hypothesis 1) and the normative models testing the influence of economic factors on acquisition value (Hypothesis 4) used the same independent variables. Namely, they included one factor related to revenues (the Payer Contracts factor) and one factor related to costs (the Operating Costs factor). Both of these factors were interacted with the for-profit and government control type variables.

Revenue in the Normative Model

The normative model considered the influence of revenue by examining hospitals' managed care participation and investment time horizon as independent variables. Information on managed care participation was derived from the AHA Database, while information on the hospital's investment time horizon was derived from the survey.

The AHA Database contains counts of the **number of HMO contracts** and **number of PPO contracts** possessed by the hospital at the time of the survey. These variables are all important because they indicate the diversity of revenue sources that the hospital has and the extent that it is exposed to uncertainty in its payments. Hospitals with many HMO and PPO contracts likely have more leverage in negotiating each one, as each contract may represent a smaller percentage of revenue. These two variables were combined into the Payer Contracts factor using the weights provided by Exploratory Factor Analysis.

Furthermore, the normative models consider the lifespan of the CT. Respondents were asked to provide estimates of the **minimum lifespan** and **maximum lifespan** of a typical CT system at their hospital. Minimum lifespan ranged from 2 to 15 years, and maximum lifespan ranged from 2 to 20 years. This variable is important because it defines the time horizon of the hospital's investment. Hospitals buying CTs with shorter time horizons for their CTs will need to have greater revenue each year to offset the cost of their acquisition than hospitals with longer time horizons.

Cost in the Normative Model

The hospital's total facility expenses, property, plant and equipment at cost, and total full-time equivalent (FTE) employees were considered for inclusion in the normative model. These numbers were all derived from the AHA database. After looking at the correlations between these variables, it became clear that total full-time equivalent employees and property, plant, and equipment at cost were relatively independent, and that total facility expenses could be excluded.

It should be noted that these variables are potentially measures of the broader construct of organizational size. Measuring personnel available to an organization (FTEs) and measuring inputs and outputs (total facility expenses and property, plant, and equipment at cost) are both means of examining organizational size (Kimberly, 1976). As a result, some correlation between these constructs is to be expected. Ultimately, the number of FTEs was highly correlated with total facility expenses (.9824), making it necessary to exclude one of the two measures. The measure of property, plant, and equipment at cost was poorly correlated with the number of FTEs (.0877) and the total facility expenditures (.0659). To manage this issue, only the measure of property, plant, and equipment at cost and the number of FTEs were retained. While these are both measures of size, one is a measure of capital and the other is a measure of labor.

The overall **number of FTE (full-time equivalent) personnel** was included as a measure of staffing and size. Hospitals with more FTEs are able to care for more patients and have higher payroll expenses. Several measures of the hospital's size were extracted from the AHA dataset. The hospital's number of staffed beds, admissions, Medicaid inpatient days, and Medicare inpatient days were all considered for inclusion as independent variables. These variables ultimately proved unusable, as information for bed staffing, admissions, Medicaid inpatient days, and Medicare inpatient days were only available for only 52, 52, 46, and 44 of the 221 responses respectively. As a result, staffing was used as a proxy for hospital volume, as staffing information was available for the majority of the responses. It is important to control for hospital size, as there is evidence that size may both enable change through enabling economies of scale and may hinder change through causing organizational inertia (Walston, Kimberly, & Burns, 2001).

The measures of hospital scale considered for use in these models was **property, plant, and equipment at cost**. Payroll expenses were not included because information on payroll expenses only was present for 52 of the 221 responses. It is important to consider expenses because hospitals differ in their expense mix. For instance, a hospital more focused on nursing and rehabilitation than treatment might have lower property, plant, and equipment expenses. The relative financial impact of a CT machine decreases as the overall size of a hospital's budget (and likely, equipment inventory) increases. Furthermore, larger hospitals are less likely to be strongly financially affected by the acquisition of a single machine than are smaller hospitals.

Performance-aspiration disparity (BTOF/PT) Models

Using the six CT machine objectives (maximizing revenue, minimizing operating costs, satisfying physician preferences, satisfying consumer preferences, providing high-quality patient care, and performing novel research) and 7-point Likert scales, respondents were asked to rate the provide ratings in response to the prompt: "Before your hospital obtained its current most valuable CT system, from the perspective of your radiology department's leadership, how well did its CT systems meet its objectives of: (followed by a list of the objectives)." A rating of '1' corresponded to "Not at all", while a rating of '7' corresponded to "Very well." This single question was meant to encapsulate both prior performance and aspirations in an integrated fashion. Answers above '4' were considered to be performance above the aspiration level, and answers below ‘4’ were considered to be performance below the aspiration level. Using an integrated measure was beneficial, as it ensured that the performance and aspirations reported related to the same construct.

After the surveys were gathered, revenue and cost were subsequently grouped into the financial factor and physician preferences, consumer preferences, and care were subsequently grouped into the customer desires factor using Exploratory Factor Analysis. For the models examining performance-aspiration disparity, the value of each factor was used as the independent variable in a separate regression, in which it was paired with the uncertainty level for that factor, which served as the independent variable. Thus, the two factors were tested separately.

Bounded Rationality Models

Like the Performance-Aspiration Disparity models, the Bounded Rationality models all separately considered different pairs of independent and dependent variables corresponding to different factors. Respondents were asked to rate each of the six objectives on a 7-point Likert scale in response to the question, “At the time of the acquisition of the current most valuable CT, how important to your radiology department’s leadership were each of the following objectives for the machine?” A rating of ‘1’ corresponded to “Not at all”, while a rating of ‘7’ corresponded to “Very important.” Responses were once again paired into the financial factor and the customer desires factor using Exploratory Factor Analysis. Each of these factors was then separately paired with the measure of uncertainty for the factor in question, with factor importance acting as the independent variable and factor uncertainty acting as the dependent variable.

Prospect Theory Models

The measure of reported uncertainty used as the independent variable in the Prospect Theory models was similar to the one used as the dependent variable for Hypotheses 1-3. However, responses were left in their raw form, instead of being grouped into factors. Once again, to determine the level of uncertainty the hospital faced before acquiring its most valuable CT system, respondents were given 7-point Likert scales for each of the objectives, and prompted to answer, "Before your hospital obtained its most valuable CT system, how certain was your radiology department's leadership of the CT's ability to meet the following objectives?" A rating of '1' corresponded to "Very uncertain", while a rating of '7' corresponded to "Very certain." Afterwards, the scale was flipped, so that a value of '1' corresponded to "Very certain" and a value of '7' corresponded to "Very uncertain." After providing the ratings, respondents were asked, "How well do you feel you recalled these uncertainties?" For this follow-up question, they were provided a 7-point Likert scale. This time, a rating of '1' corresponded to "Very poorly" and a rating of '7' corresponded to "Very well".

3.3.3: Control Variables

A variety of control variables were included in the models. To enable apples-to-apples comparisons to be made, the same set of control variables were included in all of the models. Since the same control variables were included in both the uncertainty and acquisition value models, variables were selected based on whether there was evidence from the literature that they might influence either.

Hospital Control Type

The AHA Database indicates the nature of the hospital's control type. This variable has been broken into three separate binary variables, indicating whether the hospital is **for-profit**, **government-run**, or **non-profit**. For the purposes of the regressions, non-profit is the omitted category. As the majority of the hospitals in the dataset are non-profit, it made sense to compare the influence of for-profit and government-run control to non-profit control.

Hospital control type was included as a control variable because it substantially influences a hospital's mission and means of financing. Holistically speaking, for-profit and non-profit organizations have fundamentally different objectives. For-profit organizations first and foremost have the objective of generating a profit for their shareholders. Non-profit hospitals may have any number of objectives, but ultimately, they are forbidden from distributing their profits to people. If they profit, they must put the money to a charitable use, such as giving it away through charity care or reinvesting it in the firm (Burns, et al., 2009). Furthermore, the organizational forms differ in their potential methods of financing investments. For-profit hospitals may take on debt or sell equity, while government and non-profit hospitals may only take on debt. Government and non-profit hospitals also have the potential to receive donations or exogenous grants from the government.

There is evidence that the effect of technological investments differs for for-profit and non-profit hospitals; Parente and Van Horne (2007) found that when for-profit hospitals invest in health IT, the effect is a reduction in the number of patient bed days and bed staffing costs, while in non-profit hospitals, the result is an increase in the quantity of services supplied. There is some evidence that non-profit hospitals are more likely to buy technologically-advanced CT machines, even though these machines may not yield higher reimbursements (Ladapo, Horwitz, Weinstein, Gazelle, & Cutler, 2009).

Given that for-profit and non-profit hospitals fundamentally differ with respect to their objective of producing a profit for shareholders, it is quite possible that the two types of hospitals will have different objectives when purchasing CT machines. Thompson and McEwen (1958) noted that "the hospital may compete with the midwife, the faith-healer, the 'quack' and the patent-medicine manufacturer, as well as with neighboring hospitals, despite the fact that general hospitals … are not usually recognized as competitive." Thus, competitive objectives will be possessed by even non-profit organizations. Nonetheless, the nature of an organization may affect the nature of its competitive objectives.

While non-profit hospitals have a firm-wide set of objectives that does not include generating a profit for shareholders, they must generate a profit in order to pay back debt or generate cash reserves to spend on new initiatives, such as expansion. They also often aim for some divisions to be profitable in order to offset losses from other, less lucrative divisions. Furthermore, while a hospital may be non-profit, if its radiologists are not salaried, they will have a vested interest in maximizing their own income. Thus, while the hospital itself is not turning a profit, the radiologists can profit from providing services.

Pauly and Redisch (1973) suggested that non-profit hospitals have the objective of maximizing physician income, in contrast to prior literature on hospital ownership and hospital objectives that had suggested that non-profit hospitals maximize the quantity and quality of care subject to a budget constraint (Newhouse, 1970; Feldstein, 1971), maximize quantity subject to a budget and quality constraint (Long, 1964), maximize weighted output subject to a budget and availability of capital constraint (Ginsberg, 1970), maximize the physical capital of the hospital (Lee, 1971), or try to treat the greatest number of patients bringing the greatest professional prestige (Reder, 1965). From these papers, it is clear that hospitals have a large number of potential objectives. Differences in objectives may cause hospitals to have differences in aspirations, uncertainties, and acquisition choices. Controlling for hospital control type helps account for this issue.

Nature of the Key Decision Maker

Respondents were asked whether the key decision maker in their hospital's CT acquisition process was an **Administrator** or **Clinician**. Some respondents indicated that it was both. As this was a minority of hospitals, only the variable indicating whether an administrator was the key decision maker was included as a control.

There is some evidence that administrators have different goals for organizations than clinicians and that they may promote different innovations than members of the clinical team. Prior literature has shown that while investors and other actors may prefer managers to be uncertainty-seeking, managers themselves may be uncertainty-averse as they have no real protection against losses specific to their firm or division and are less able to reduce it through diversification as an investor can (Mayers & Smith, 1982;

Coffee, 1986; Greenwald & Stiglitz, 1990). As clinicians build their reputations on their medical competence rather than their administrative competence, their careers may be less harmed than those of administrators in the event a poor investment is made that irreparably distresses the hospital. Furthermore, different types of decision makers may have different attitudes towards technology. It has been shown the involvement of the chief medical officer in administrative activities promotes the adoption of technological innovations (Kimberly & Evanisko, 1981).

Respondent Characteristics

It is possible that responses were biased by the respondent's characteristics. As respondents whom were the key decision maker in the acquisition process may have been privy to a greater amount of information than those whom were not, I controlled for whether the **respondent is the key decision maker**. Furthermore, for the same reasons that I controlled for whether the key decision maker was an administrator, I controlled for whether the **respondent was a physician** (had an MD or DO). Physicians may be more attuned to issues related to customer desires and demand (i.e. how well machines satisfy physician preferences, consumer preferences, and the needs of care), and less attuned to issues related to operating costs and the revenue the CTs generate for hospitals. **Respondent tenure** was likewise included as a control, as more senior respondents may be considering a wider (and older) universe of CTs when formulating their responses. Finally, the **source** of the response was included as a control, as the propensity of marginal respondents to respond may have differed depending on whether the survey arrived via the mail, was distributed by a colleague, or was administered by the experimenter in person.

Hospital's Multi-hospital Organization Membership

Membership in an entity containing other hospitals may influence both the uncertainty a hospital has when acquiring a CT machine and the price at which it is able to acquire it. These multi-hospital organizations may share information on CT performance, reducing the uncertainty of their members. Furthermore, they may engage in collective bargaining with manufacturers, reducing the actual price at which equipment is acquired.

The AHA Database contains both a binary variable indicating whether the hospital is a **member of a system**. A hospital system is a group of two or more hospitals managed, owned, or sponsored by a common entity. Systems may be able to share resources between member hospitals if they are geographically-proximate and may be able to use the patient volume produced by the system as leverage in negotiations with both insurers and vendors. Thus, system membership may influence the cost at which a hospital can acquire a CT machine and the degree of uncertainty a hospital has during the process.

The dataset contains both a binary variable indicating whether the hospital is a **member of a network** and an additional variable uniquely identifying the network to which the hospital belongs. A hospital network is a collection of hospitals that coordinate their delivery of services to a community. They tend to consist of hospitals that are geographically-proximate, and may be able to use their joint decision making ability as leverage in negotiations with insurers and vendors.

There is evidence that alliances influence both hospital behavior and the revenues and costs experienced by hospitals. Jiang (2009) found that system hospitals with local partners have lower adoption rates of MRI technology; an effect with strengthens the closer the hospitals are to partners whom have already adopted. However, system hospitals without local partners behave like independent hospitals, and in general, have higher rates of adoption. Nonetheless, there is somewhat contradictory evidence that the horizontal integration increases the marketing efficiency and market power of hospitals, but not the efficiency or quality with which services are produced (Dranove, Durkac, & Shanley, 1996; Cuellar & Gertler, 2005).

The effect of the presence of non-local hospitals within hospital systems is unclear. Krishnan (2001) found that hospital mergers and acquisitions result in price increases which are based upon the market share that the hospital system has at the Diagnosis Related Group (DRG) level, indicating that system creation influences revenue generation. In contradiction, Young, Desai, & Hellinger (2000) found that hospitals that exerted market power through higher prices did so to a greater extent when nonlocal hospitals were in their systems. Overall, the influence of system status on pricing power has been demonstrated in situations in which hospitals both have and lack other system members in their local markets (Melnick & Keeler, 2007).

The models all also control for whether the CT machine was **purchased** or not. This information was obtained from the survey responses. Leasing offers greater flexibility when a hospital has uncertainty over the intended lifespan of its equipment, and may be preferable in these situations (Bierman & Smidt, 1984).

Experience with CT Systems

To understand how brand experiences may have impacted responses, respondents were asked to indicate the brands of CT currently installed at the hospital, formerly installed at the hospital, experienced during prior employment, and rented by the hospital (as a mobile unit). Checkboxes were provided for each of these categories for the following brands: GE, Hitachi, Philips, Siemens, Toshiba, and Other.

To avoid only being able to make brand-specific conclusions, in addition to the problem of having 24 brand experience-related variables, the control variables used in the model were composite measures constructed from the variables on the survey. One such control variable was a measure of the **number of brands experienced.** For each brand, this variable was set to 1 if the respondent had ever encountered the brand in question through it being currently installed at the hospital, formerly installed at the hospital, experienced during prior employment, or rented by the hospital. The variable was set to 0 otherwise. These variables can be used to determine whether a respondent's encounters with a brand influence his or her acquisition decisions.

Two other variables were included as controls for brand experience in the model. These two variables, unlike the brands experienced control, do not consider the experiences of the respondent. Instead, they only consider the experiences of the hospital. The **new brand** binary variable was set to 1 if a brand that previously had no presence at the hospital made the current most valuable CT machine. Meanwhile, the **same brand** binary variable was set to 1 if the current most valuable CT was made by the same brand as the hospital's prior most valuable CT. Hospitals in which the current and prior most valuable CTs are of the same brand have more up-to-date information on the capabilities of the machines offered by that brand.

Cost of Capital

As the prices used as proxies for the value of the most valuable CT are not the true prices that the hospitals paid to buy or lease the machine, but instead the present values of the machines in question, it is necessary to control for factors that might influence the cost of capital for either the hospital or the firm leasing the machine to the hospital. To account for this, the models control for the number of **years elapsed since the most valuable CT (MVCT) was acquired** and the **London InterBank Offered Rate (LIBOR)** in the January of the year of acquisition. The age of the machine is important to consider, as prices of CT machine models decline over time. While the rates at which firms can borrow money is generally above LIBOR by a fixed amount (depending on credit risk), as LIBOR rises, the cost of debt rises as well.[5]

Hospital Mission

Rural location and Catholic leadership may influence the mission of a hospital, and as a result, the present value of the CT machine the hospital ultimately choses to acquire. To account for this, I have included variables indicating whether the hospital is **Catholic-operated**, a **Critical Access Hospital**, a **Rural Referral Center**, a **Sole**

[5] LIBOR rates taken from a table at http://www.wsjprimerate.us/libor/libor_rates_history.htm on January 19, 2011

Community Provider, and a **Community Hospital**. Hospitals that are situated remotely face different competitive pressures than hospitals which are situated near other hospitals. Namely, they face less competition for patients. On the other hand, if they lack a technology needed to provide care, they are less able refer patients to other hospitals than are hospitals situated near other hospitals.

3.3.4: Other Variables

There are a number of other variables that were included in the survey which were not included in the models. A number of them are described throughout this study for other reasons. Namely, they were useful in determining the characteristics of the respondents.

In order to avoid anchoring the responses of the respondents on something outside of their own perceptions, at the beginning of the survey, respondents were asked to provide brief statement on why their hospital acquired the current most valuable CT system. These free-text responses were not analyzed. After providing the statement, respondents were asked to choose one of five checkboxes best explaining their motive for acquiring the most valuable CT machine. The options were: **capacity expansion**, **competitive action**, **contract expiration**, **leadership changes**, and **tech developments**. While respondents were only supposed to select the strongest motive, several selected multiple responses. Results are reported in Table 10. Respondents were also asked whether they perceived the acquisition of the most valuable CT machine would be profitable before the acquisition occurred.

Determining Respondent Eligibility

Respondents were asked the **year that they joined their present hospital**. If this year was greater or equal to the year in which the current most valuable CT machine was acquired, their response was marked as being less reliable. Likewise, respondents were asked to rate their **confidence in their responses** on the survey using a 7-point Likert scale. A rating of '1' indicated "Not at all" and a rating of '7' indicated "Very strong". Surveys in which confidence was rated as less than '4' were marked as being less reliable. All of the models in this study were run twice. The first time, they were run using the full dataset. The second time, they were run using the usable responses dataset, excluding respondents whom were either not confident in their responses or not present at the time of acquisition.

Pairing the Survey to the AHA Database

Respondents were asked to indicate the name of their hospital. This response was used to pair survey responses with data from the 2008 American Hospital Association Annual Survey. When a precise match could not be found, Google Maps was used to determine likely addresses corresponding to the survey respondent's hospital. Those addresses were then matched against the hospital addresses in the AHA Database.

3.4: Descriptive Statistics

Table 3 and Table 4 contain descriptive statistics for the variables previously mentioned. The percentage of respondents that assigned a value of '0' or '1' or '1', '2', '3', '4', '5', '6', or '7' are listed in the table, with a rating of '7' being the highest. Note that only 5% of hospitals rated the importance of the objective of providing high-quality care as less than '4', and only 6% of hospitals gave such a rating to the objective of satisfying physician preferences. The objective with the greatest standard deviation was research, which was likely due to the fact that some hospitals reported that they performed no research whatsoever, while others were research institutions.

Table 3 contains summary statistics for the full dataset, while Table 4 contains summary statistics for the most usable responses. Throughout this dissertation, all computations will be performed on both the complete dataset and the most usable subset. Note that only about 6% of responses came from respondents with confidence less than '4'. Nonetheless, about 16% of respondents were not employed by their present hospital in the year prior to the acquisition. Ultimately, 80% of the dataset came from respondents who were both present and confident in their responses.

Insert Table 3 about here

Insert Table 4 about here

Correlation tables for the key variables examined in this dissertation are presented in the Supplemental Tables section of the Appendix. The correlation tables also include correlations with factors combining multiple variables. (A description of how the factors were generated is presented in Section 3.5, the Method section.) Each of the correlation tables, Table 20 through Table 27 (in the Supplemental Tables section), was computed using either the full dataset or the most usable responses. As a result a different table is presented for each dataset.

From Table 5 and Table 6, it appears that the majority of respondents were employed at hospitals that upgraded to 64-slice CT. The majority of the prior most valuable CT machines were 16-slice CTs. Nonetheless, some of the more advanced hospitals upgraded from a 64-slice to a 128, 256, or 320-slice CT. These general conclusions held both for the full sample and for the more limited usable response sample.

Insert Table 5 about here

Insert Table 6 about here

In both the full sample (Table 7) and the usable responses subsample (Table 8), the most common year for the most valuable CT machine to have been acquired was 2008, followed by 2010. This likely is a result of the depression that negatively impacted America from 2008 onwards. In 2009, the market suffered from much uneasiness, which was reduced in 2010 (Aunt Minnie, 2011). Overall, 86% of the respondents in the full sample worked at a hospital that had acquired the most valuable CT within the past five years, and 60% had experienced such an acquisition within the past three years. In the reduced sample, 90% of respondents were employed at a hospital that had acquired the most valuable CT within the past five years, and 65% were employed at a hospital that had made the acquisition within the last three years. Thus, the vast majority of respondents provided answers based upon rather recent events at their hospitals.

Insert Table 7 about here

Insert Table 8 about here

As can be seen from Table 9, the majority of hospitals have a CT on premises. However, only about a third has an advanced machine with 64 or more slices. The majority of CT machines are situated in non-profit, non-governmental hospitals. Due to the use of a Texas subsample, statistics on Texas CT possession have also been provided. In Texas, slightly fewer hospitals have a CT on premises; 69%. Advanced machines are also a bit rare in Texas, possessed by only 24% of hospitals.

Insert Table 9 about here

As is shown in Table 10, technological developments and capacity expansion were by far the most common motives for acquiring the most valuable CT machine, with competitive action being a distant third. Contract expiration and leadership changes were not common motives for the acquisition. Other data from the survey showed that overall, 91% of respondents perceived that the CT acquisition would be profitable before it occurred. Among the 18 respondents who perceived that the CT acquisition would not be profitable, 6 reported that the acquisition had been made for capacity expansion, 2 reported it had been made for competitive reasons, and 10 reported it had been made due to technological developments. None cited contract expiration or changes in leadership as a motive. Thus, it appears that while profit played a role in the decision making process, for the minority of acquirers for whom it did not, technological developments were the dominant motive.

Insert Table 10 about here

3.5: Method

In order to make the models tested in this paper as parsimonious as possible, each was run in roughly the same fashion. All were tested using Ordinary Least Squares (OLS) regression. OLS seemed appropriate as the dependent variables for both the uncertainty and CT value models are ordinal variables. As a result, the coefficients in the results tables are easily interpreted. In the tables in which attribute uncertainty is the dependent variable, coefficients indicate the extent to which a change in the variable value changes the level of attribute uncertainty. Likewise, in the tables in which the present value of the most valuable CT machine is the dependent variable, the coefficients indicate the extent to which a change in the variable values changes the present value of the most valuable CT acquired.

3.5.1: Method for Examining Factors Influencing Uncertainty

Simplifying the Dataset through Exploratory Factor Analysis

While the respondents were asked to answer questions along six dimensions (revenue, costs, physician preferences, consumer preferences, care, and research), it is not necessarily the case that all of the respondents maintained six distinct dimensions in their heads. It is quite possible that instead, the respondents maintained a smaller number of more simplistic dimensions. If this were the case, for example, answers to separate questions on revenue and cost might really both be derived from a common perception of profitability.

Exploratory factor analysis (Spearman 1904, 1927) is a statistical method that attempts to explain response data by generating factors which are linear combinations of the response variables. The factors are fewer in number than the response variables that were used to derive them and thus using factors allows variability to be described using fewer variables. As the number of factors that can be computed is potentially equal to the number of variables inputted into the computation, criteria must be used to determine which factors to retain and which to discard. Two common methods for determining which factors to retain are the Kaiser criterion (Kaiser, 1960) and the scree test (Cattell, 1966). I computed factors using the principal factor method for the six uncertainties, objective strengths, and performance-aspiration disparities. In each of the three cases, the Kaiser criterion suggested that a single factor would explain all six attributes, while the scree test suggested that two factors would explain all of the attributes besides research, which was not strongly correlated with any factor.

The two factors suggested by exploratory factor analysis were one consisting of revenue and cost and another consisting of physician preferences, consumer preferences, and care. For simplicity, I will refer to the first factor as the "financial" factor and the second factor as the "customer desires" factor. Patients and physicians are both in essence customers of the CT machine. Patients desire CT machines to both provide care and to provide the peace of mind that comes from knowing a certain technology has been used. While more advanced CT machines do not always provide patients with a clinical benefit, patients may desire them nonetheless if they are unaware of the lack of benefit or feel that an advanced machine is a proxy for general state-of-the-art care. Physicians are also a customer of the CT machine, as they sell physician services as complement to the hospital services that the CT machine provides.

I created each of the factors by combining their components in equal proportions. Thus, a 1-point higher response on a scale related to revenue increases the financial factor by half a point, and a 1-point higher response on a scale related to physician preferences increases the customer desires factor by a third-point. As a result of using this construction, it is easier to interpret the coefficients in the results section.

A factor was also created to simply the independent variables. Two measures of payer contracts (HMO contracts and PPO contracts) were included in the normative models. The measures of HMO contracts and PPO contracts were weighted equally to create the payer contracts factor. As a result, the coefficient represents the change that would result from the addition of either an HMO or PPO contract.

In all of the models examining factors influencing uncertainty, an OLS regression was run with controls for for-profit status, government status, system membership, network membership, purchasing group membership, whether the valuable CT was purchased or leased, whether the most valuable CT was a new brand, whether the most valuable CT was the same brand as the prior most valuable CT, the total number of brands experienced, the years elapsed since the most valuable CT was acquired, and LIBOR in January of the year of acquisition. There were also two hospital mission controls. Namely, whether the hospital was Catholic Church operated and whether it was a Critical Access Hospital. The models likewise controlled for a series of respondent characteristics: whether the respondent was the key decision maker, whether the respondent was a physician, the tenure of the respondent, and the source of the response.

The dependent variable in each of the models corresponded to the level of uncertainty reported by the respondents. Separate models for each factor were run to test the Behavioral Theory of the Firm and Bounded Rationality. While this was also done for the normative models, the factors that served as independent variables in these models corresponded to the hospital's number of payer contracts and operating costs.

Model for Testing Normative Theory

Hypothesis 1 was tested using OLS regression using the following equation:

$$\begin{aligned} FinancialUncertainty &= \beta_0 + \beta_1 PayerContracts \\ &+ \beta_2 PP\&E + \beta_3 FTEs + \beta_4 MinCTLifespan + \beta_5 MaxCTLifespan \\ &+ controls + \varepsilon \end{aligned}$$

If β_1 is negative and significant, it will suggest that financial uncertainty decreases as payment diversity increases. If β_2 and β_3 are negative, it will suggest that financial uncertainty decreases as the overall scale of operating costs (both from plant and personnel) increases. If β_4 and β_5 are positive and significant, it will suggest that the firm has a greater amount of financial uncertainty the longer its investment timeline.

Model for Testing the Behavioral Theory of the Firm

Hypothesis 2 examines how the disparity between prior performance and prior aspirations influence the uncertainty in the performance of the machine ultimately selected. For each of the two factors (Financial and Customer Desires), I ran the following Ordinary Least Squares (OLS) regression:

$$Uncertainty_X = \beta_0 + \beta_1 PerformanceAspirationsDisparity_X + \varepsilon$$

After running the regression, I plotted the results and reported them in a table. Given that not all of the respondents were present in their hospital at the time of the acquisition of the most valuable CT, or were confident in their findings, I reported findings from both the full sample and the most usable subsample.

Model for Testing Bounded Rationality

To test whether hospitals have less uncertainty about strongly held objectives (Hypothesis 3), I ran the following regression for each of the factors using OLS:

$$FactorUncertainty_x = \beta_0 + \beta_1 FactorImportance_x + controls + \varepsilon$$

A negative coefficient on β_1 would indicate that Hypothesis 3 holds, and that hospitals are more certain about machine attributes that are related to objectives that are considered to be more important.

3.5.2: Method for Examining Factors Influencing Acquisition Value

The first of these two models is meant to test how the direct inputs into revenue and cost uncertainty influence the machine's present value, while the second is meant to test how reported perceptions of uncertainty influence the present value of the current most valuable CT. As was the case with the models examining the determinants of uncertainty, each factor is considered separately. All of the models were run twice; the first time with the complete dataset, and the second with only the most usable responses. The dependent variable for Hypotheses 4 and 5 is the present, fair market value of the most valuable CT machine. Thus, this variable is a large integer. While it is technically bounded by (0,∞), the minimum value it is likely to take is so far from zero that Ordinary Least Squares (OLS) regression may be used.

Model for Testing Normative Theory: Revenue

Hypothesis 4 was tested for revenue using OLS regression using the following equation:

$$PresentValueMostValuableCT = \beta_0 + \beta_1 PayerContracts + \beta_2 MinCTLifespan + \beta_3 MaxCTLifespan + controls + \varepsilon$$

If β_1 is positive and significant, it will suggest that investment increases as payment diversity increases. If β_2 and β_3 are positive and significant, it will that the longer the investment timeline, the more the firm can invest.

Model for Testing Normative Theory: Cost

Hypothesis 4 was tested for the cost attribute using OLS regression using the following equation:

$$PresentValueMostValuableCT = \beta_0 + \beta_1 PP\&E + \beta_2 FTEs + \beta_3 MinCTLifespan + \beta_4 MaxCTLifespan + controls + \varepsilon$$

Hypothesis 4 will be supported if the coefficients on all the independent variables are positive and significant. This would suggest that hospitals are willing to invest more if their overall expenses are greater. Furthermore, a longer time horizon for the investment may encourage increased investment, as the hospital will then be able to spread the fixed costs of the CT machine over a greater number of years.

Method for Testing Prospect Theory

The model used to test Hypothesis 5 has the following form:

$$Value\ Of\ Most\ Valuable\ CT = \beta_0 + \beta_1 Uncertainty_x + controls$$

Note that this model will be run separately for revenue uncertainty and cost uncertainty. If the coefficient β_1 is negative and significant when the uncertainty variable deals with revenues and positive and significant when the uncertainty variable deals with costs, then Hypothesis 5 will be supported.

Chapter 4: Results

4.1: Determinants of Uncertainty

4.1.1: Overview of the Results

A summary of the findings of all of the models in this study is presented in Table 20. For each of the hypotheses, I have indicated the expected sign, observed sign, and significance of each of the independent variables. In the first stage of the model, examining the determinants of uncertainty, Hypotheses 2 (behavioral) and 3 (Bounded Rationality) were supported, but Hypothesis 1 (normative) was not. In the second stage of the model, examining the determinants of acquisition value, Hypothesis 4 (normative) had very weak and partial support, while Hypothesis 5 (behavioral) had no support. Subsequent investigation revealed that while financial uncertainty had no relationship to the value of the CT acquired, customer desires uncertainty (not featured in Table 20 or the hypotheses) played a significant role in determining the value of the most valuable CT.

Hypotheses 1, 2, and 3 examine whether the normative economic theory (1), the Behavioral Theory of the Firm (2), Prospect Theory (2), and Bounded Rationality (3) can be used to predict the uncertainty that a firm experiences while acquiring equipment. The models run to examine these three potential determinants of uncertainty were crafted to be as parsimonious as possible. As a result, they only differ in their independent variables. All the models also contain interaction terms in which the independent variables are interacted with controls for for-profit and government status. These interactions were conducted in a consistent way as well. The degree of parsimony makes comparing the theories possible.

As not all of the respondents were highly-confident in their responses or present at the time of acquisition, all of the models were run twice. The first time, they were run using the full dataset. The models were all run an additional time using only responses from respondents that were present at their hospital in the year prior to the acquisition and whom self-rated the reliability of their responses as 4 out of 7 or greater.

As is shown in Table 12, increased CT maximum lifespan was significantly and negatively associated with financial uncertainty in the normative model using the full dataset, but not the model conducted using the most usable responses. Payer contracts, property, plant, and equipment, and FTEs were not found to be significantly associated with financial uncertainty. Thus, no support was found for Hypothesis 1. I had hypothesized that financial uncertainty would increase as the time horizon of the investment increased, but in fact it declined. The time horizon of a durable capital investment in part determines the volume of usage it may experience before retirement. While I had hypothesized that hospitals have less financial uncertainty about longer investments because they have more years to make back their sunk costs, this was not found empirically. Furthermore, it is possible that the financial measures were not significantly related to perceived financial uncertainty because the respondents were not aware of their values when answering the survey. My pilot study revealed that respondents were ignorant of the values of variables that could be used to determine the profitability of their CTs.

Table 13 shows that the performance-aspiration disparity for both the financial factor and the customer desires factor were both negatively and significantly associated with their respective uncertainties for all the models. Thus, Hypothesis 2 was fully supported by the models. This implies that there is support for the behavioral theories on the determinants of uncertainty. Higher levels of uncertainty were associated with prior performance below aspirations, while lower levels of uncertainty were associated with prior performance above aspirations.

Consistent with Hypothesis 3, Table 14 shows that both financial factor objectives and customer desires objectives were highly significant in explaining uncertainty and had a negative relationship with uncertainty. This was the case for both the models tested using the full dataset and the most usable responses. Although both objective strength and performance-aspiration disparity were found to be highly-significantly predictive of uncertainty, the adjusted R^2 was slightly greater for objective strength.

Given that all three models significantly predict uncertainty, it is important to attempt to determine which model does the best job of doing so. Adjusted R^2 is a measure of goodness of fit which accounts for the number of explanatory terms in a model. Unlike R^2, adjusted R^2 accounts for whether improvements in models resulting from the addition of explanatory variables are greater than what would be expected by chance.

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Insert Table 11 about here

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As can be seen in Table 11, some of the models provide a far better prediction of the uncertainty experienced by the firms than others. The value of the financial uncertainty and customer desires uncertainty factors appear to be best predicted by the Bounded Rationality models which used objective strength as a predictor. The worst predictions of financial factor uncertainty were made by the economic models, which used payer contracts and operating costs as predictors. Performance – aspiration disparity was slightly less predictive than objective strengths, and both substantially outperformed the economic factors. The same relative ranking held for both the full dataset and the usable responses dataset.

Similar trends held for the relative significance of the independent variables as well. In all cases, the independent variable(s) were extremely significant in the behavioral and Bounded Rationality models and least significant in the economic model. The models are all relatively comparable, as they include the same dependent variables and control variables, and only differ in the independent variables that they include. While the traditional economic measure of investment horizon has some predictive power for determining financial uncertainty, the perceptual measures have greater predictive power. Thus, while all three theories predict uncertainty in some contexts, not all do so equally well.

4.1.2: Normative Theory

Two normative models of the determinants of uncertainty were run (Table 12), one with the full dataset and the other with the most usable responses. The models each contained the payer contracts factor, property, plant, and equipment at cost, FTEs, minimum CT lifespan, and maximum CT lifespan as independent variables. Of these, only maximum CT lifespan was significantly associated with financial uncertainty. Maximum CT lifespan was only significant when the full dataset was used and had a negative relationship to uncertainty – the opposite of what was predicted.

Insert Table 12 about here

The two models suggested that there may be other factors at play in determining the financial uncertainty perceived by hospitals during the CT acquisition process. The only control variable which was significant, whether the respondent was a physician, had a negative impact on financial uncertainty in both models. Physicians have a general propensity to report lower financial uncertainty. The mean of the financial uncertainty factor was .92 lower for physicians than for non-physicians. This is equivalent to reporting about 1 point less revenue uncertainty and 1 point less cost uncertainty on the two 7-point Likert scales on the survey.

4.1.3: Behavioral Theory of the Firm

The models all suggested a highly significant and negative association between a performance-aspiration disparity on both the financial and customer desires factors and the respective measures of uncertainty (Table 13). That is, firms whose prior performance underperformed aspirations tended to buy machines about which they had more uncertainty, while firms whose prior performance outperformed aspirations tended to buy machines about which they had less uncertainty. This relationship held for both the full dataset and the most usable responses dataset.

Insert Table 13 about here

For-profit hospitals had less financial uncertainty than non-profit hospitals in both the full and usable dataset models. For-profit hospitals did not have significantly different customer desires uncertainty than non-profit hospitals. Government-controlled hospitals had no difference in perceived uncertainty relative to non-profit hospitals. The full dataset model suggested that for-profit firms on average reported about .7 points less revenue and cost uncertainty than non-profit firms. In the more usable sample, this difference jumped to 1 point less on average for the two categories.

A number of the other control variables were significant as well. Physicians reported .8 points lower financial factor uncertainty, but did not have significantly different customer desires uncertainty from non-physicians. This is somewhat surprising, as physicians were one of the customers considered by the measure of customer desires uncertainty. Lower interest rates were associated with significantly lower financial factor uncertainty for the full model, and nearly significantly lower financial factor uncertainty ($p=.089$) for the usable responses model. A 1% increase in the LIBOR interest rate was associated with about .1 points lower reported financial uncertainty. This makes sense, as a lower interest rate suggests that the machines are less expensive to acquire, and if all else is equal, more profitable. Additionally, Catholic status was associated with lower financial and customer desires uncertainty. While this was only significant for one of the models, it was nearly significant ($p<.15$) for three of them. Catholic status was associated with between .3 and .5 points less uncertainty on both of the factors. Catholic hospitals may have slightly different sets of objectives than non-Catholic hospitals, and as a result, slightly different perception of how well prospective CTs fulfill those objectives.

Finally, the respondents who received the survey from their colleagues or took the survey online reported significantly more uncertainty than the RSNA respondents. Respondents whom were asked to take the survey by colleagues might have been more likely to complete the survey than equally-uncertain individuals whom were not given the survey at the request of a colleague. As a result, more marginal respondents may have entered this sub-sample. The mean confidence in responses was 5.74 out of 7 points for respondents whom did not receive the survey from a friend. Among people who were urged to take the survey by a friend, the mean reported confidence dropped to 5.20 out of 7 points. Among people who took the survey online, the mean confidence was only 5.00 out of 7 points. Some of the online responses were a result of colleague referrals. This supports the notion that colleagues tended to be less confident responders than people whom were willing to take the survey without collegial prodding.

One issue that has been explored in the Behavioral Theory of the Firm literature is the shape of the relationship between the performance-aspiration disparity and uncertainty (Bromiley, 1991; Greve, 1998, 2003; Audia & Greve 2006). While Table 13 demonstrated an overall negative relationship between the disparity and uncertainty, it did not precisely show how the two variables were related at different levels of disparity. To show these relationships more precisely, I discretized the disparity measure for each of the six machine attributes into a series of dummy variables, each equal to one response level on the survey. The omitted category is 0, when performance is equal to the aspiration level.

To center the measure of disparity, I assigned the lowest level disparity responses (1) the value -3, and the highest level disparity responses (7) the value 3. Respondents whom felt that performance was at aspiration levels (responses of 4) were assigned the value 0. I then ran simple OLS regressions with the reported level of uncertainty for the attribute as the independent variable and the six discretized disparity dummy variables as the dependent variables. Table 28 and Table 29 (in the Supplemental Tables section) contain the results of the regressions for the full and more usable responses models respectively. From the tables, you can see that the larger the magnitude of the disparity, whether positive or negative, the more significantly predictive of uncertainty it was. Figure 5 and Figure 6 visually display these relationships for the full and more usable responses respectively. The X-axis of the figures corresponds to the reported level of performance-aspiration disparity for the attribute. The Y-axis of the figures corresponds to the coefficient on that level of disparity shown in Table 28 or Table 29. Effectively, the Y-axis represents the impact on uncertainty of a firm possessing a given level of disparity. These tables and figures suggest that a significant relationship exists between performance-aspiration disparity and uncertainty for all of the attributes considered except care. The relationship appears to be more significant for the tails – very high and very low levels of the disparity – than for more middling values in which performance is near the aspiration level.

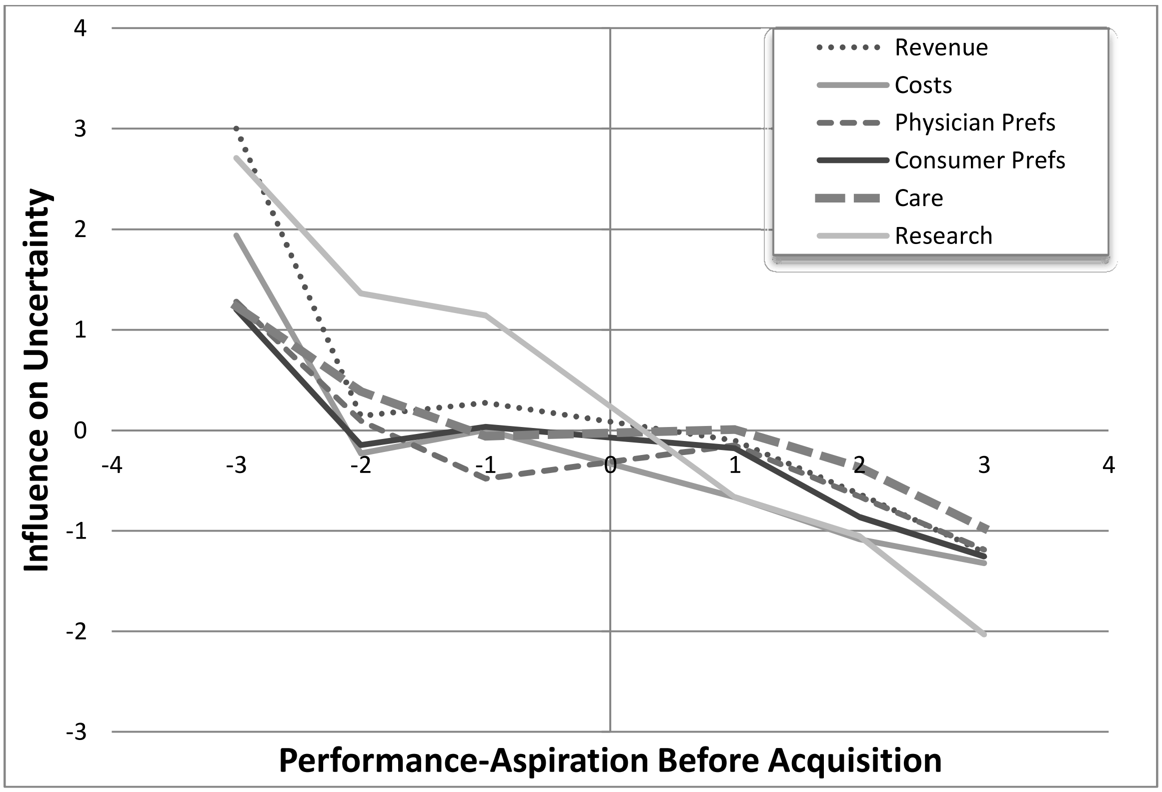


Figure 5: Performance-Aspiration Disparity vs. Uncertainty, Full Sample

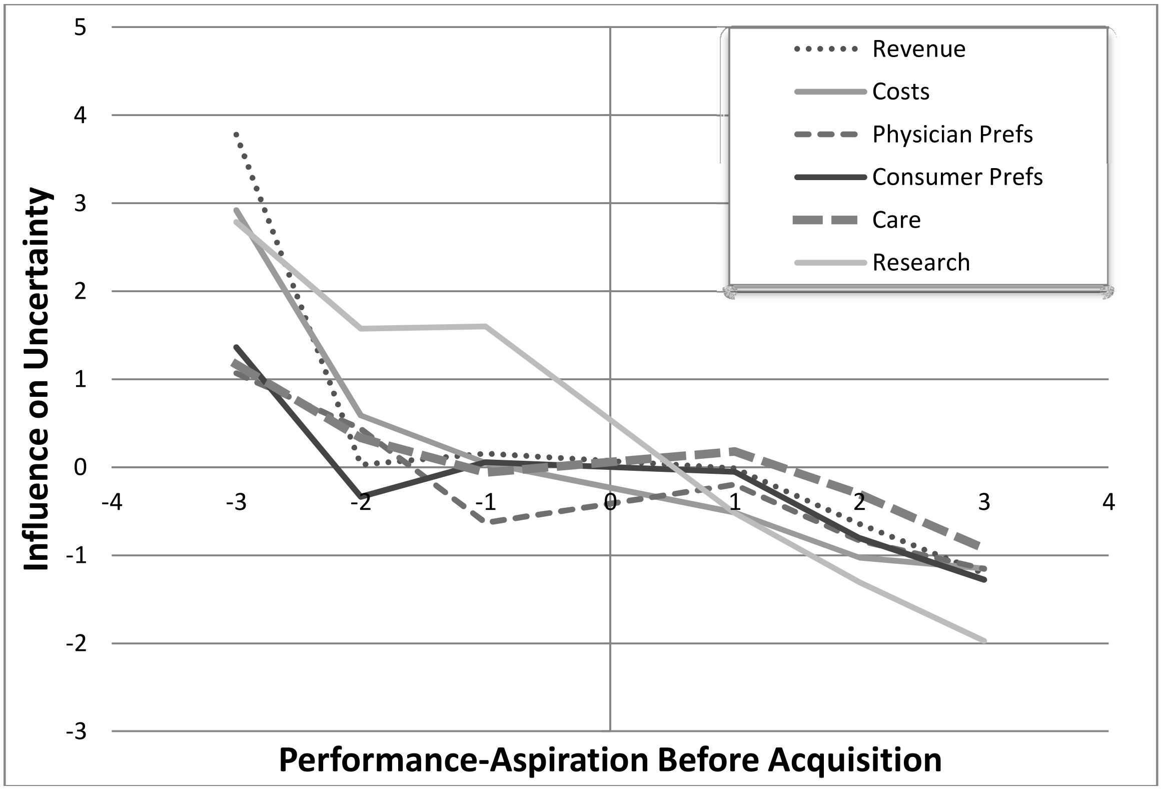


Figure 6: Performance-Aspiration Disparity vs. Uncertainty, Usable Responses

The various levels of the performance-aspirations disparities were not always significantly related to uncertainty. This may in part be due to the fact that some levels of performance-aspiration disparity were held by greater numbers of hospitals than others, resulting in variation in the statistical power of the comparisons. The relationship tended to be less significant for levels of performance closer to aspirations and for levels of performance below aspirations. The measure of performance-aspiration disparity was a scale that was converted into a series of binary variables, with the omitted value being 0. It makes sense that values of the disparity far divergent from 0 are more likely to be statistically different in their influence on uncertainty than are values closer to 0. All in all, while the graphs are not monotonic for all of the objectives, they generally suggest support for findings congruent with the literature (Bromiley, 1991; Greve, 1998, 2003; Audia & Greve 2006).

Overall, this exploration has shown that a firm's willingness to experience uncertainty on an attribute of its acquisition is related to its experiences with its prior most salient acquisition. Firms that felt their prior performance exceeded aspiration levels were less likely to take a chance on an uncertain machine, while firms that felt that their prior performance fell short of aspiration levels were more willing to take a chance on an uncertain machine. While this finding is hardly novel, in the past it has been examined through external measures of firm uncertainty-seeking, rather than through the self-reported uncertainty assessments of individuals involved in the decision making process.

4.1.4: Bounded Rationality

The best explanation of a firm's financial uncertainty and customer desires uncertainty during the investment process is the extent to which it treats both factors as objectives. The stronger the objectives are held, the less uncertainty firms have about their future CT's ability to meet them (Table 14). In both models, the strength of the financial factor objective was negatively related to financial factor uncertainty, and significant at a very high level ($p<.001$ for three of the models, and $p<.005$ for the customer desires model using the most usable dataset). An increase in the importance of a factor by 1 was associated with a decrease in uncertainty for that factor of about .4. The magnitude and significance of this relationship was relatively similar for both the financial and customer desires factors.

Insert Table 14 about here

Although it was not significant ($p<.15$ for the full dataset, and $p<.06$ for the more usable responses), for-profit hospitals tended to have about half a point less financial uncertainty than non-profit hospitals. For-profit status did not influence customer desires uncertainty. If for-profit firms have the primary objective of maximizing profits, it makes sense that they would make investments for which they perceive less financial uncertainty than would non-profit hospitals, which have a number of objectives.

As was the case with the behavioral theory models, physicians had significantly less financial uncertainty than non-physicians (.5 points less for the full dataset, .8 points less for the most usable responses). Likewise, Catholic hospitals reported less perceived financial uncertainty as well (.4 points less using the full dataset, $p<.1$, and .5 points less using the most usable responses, $p<.05$). Furthermore, colleague and online responses reported significantly more financial uncertainty. As I mentioned previously, these responses were self-perceived as being of lower quality, and may have come from more uncertain and less well-informed respondents.

Overall, Bounded Rationality appears to be the best explanation of firm uncertainty during the acquisition process. Going forward, it may make sense for those wishing to examine hospital uncertainty to focus on hospital objectives, rather than solely on hospital characteristics or the perception of a performance-aspiration disparity. The predictive power of objectives was robust to both the nature of the objective and the quality of the responses considered.

4.2: Determinants of the Present Value of the Acquisition

4.2.1: Overview of the Results

Hypotheses 4 and 5 examine the implications of using normative economic theory (4) and Prospect Theory (5) models to predict the value of CT machines acquired. The economic theory hypothesis was partially supported, and the Prospect Theory hypothesis was not supported. Nonetheless, exploring the impact of perceived uncertainty on acquisition value led to the unanticipated finding that uncertainty related to customer desires has a negative impact on the value of acquisitions.

The models used to test these two hypotheses were initially designed to be highly parsimonious, only differing in their independent variables and interaction terms. Non-financial machine attributes were not considered in the initial comparison, as there are no measures of non-financial uncertainty stemming from the normative model. After the initial comparison, I also examined how non-financial uncertainty influenced the present value of the acquisition. I was surprised to find that non-financial measures of uncertainty were more predictive of the ultimate value of the acquisition than were the normative measures and the measures of financial uncertainty observed through the survey.

When testing Hypothesis 4, a significant and positive relationship was found between minimum lifespan of the CT machine and acquisition value in the model in which the payer contracts factor was considered and only the most usable responses were used. While this provides little support for Hypothesis 4, it also does little to go against the notion that hospitals behave in a profit-maximizing fashion. The traditional economic model of firm profit-maximization suggests that firms do not consider uncertainty when making investment decisions, but instead consider factors influencing the revenue, costs, interest rate, and time horizon of their investments. Thus, economists may find it unsurprising that these accounting proxies for uncertainty do not appear to significantly influence spending. They may further be unsurprised to find that the time horizon of the investment (minimum lifespan), which does influence profitability, is significant.

The level of revenue and cost uncertainty reported by the respondents on the survey had no relationship to the present value of the most valuable CT machine. In fact, the relationship between cost uncertainty and acquisition value flipped sign between the full and more usable datasets. Prospect Theory suggests that higher revenue uncertainty might be associated with lower acquisition values, while higher cost uncertainty might be associated with higher acquisition values. This was not found.

One of the reasons that financial uncertainty may not have had a significant impact on acquisition value is that the acquirers may have been relatively financially insensitive. Non-salaried physicians are compensated for the services that they provide interpreting scans, not for anything related to the acquisition cost, operating costs or price of scans produced by the machine. As a result, physicians may favor machines that encourage large volumes to come to them for care, and encourage them to seek scans requiring more expensive interpretation services. This compensation model makes physicians insensitive to the sunk and operating costs of their imaging equipment, unless the costs interfere with continued operation of the department or constrain the department from acquiring other desired equipment. It appears that acquisition value is significantly determined by the hospital's level of uncertainty about whether the machine will fulfill customer desires rather than profit, supporting this notion.

While Hypothesis 5 was not supported, examining the hypothesis caused me to further examine how non-financial forms of uncertainty influence acquisition value. (Prospect Theory does not provide any predictions on this, as it is not clear whether these forms of uncertainty are viewed as gains or losses.) Ultimately, it was found that increased physician preference, consumer preference, and care uncertainty were all significantly associated with lower acquisition present values. A 1 point increase in physician preference uncertainty was associated with $96,000 lower value, while a 1 point increase in consumer preference uncertainty was associated with $78,000 lower acquisition value. The impact of care uncertainty was the greatest, with a 1 point increase associated with $100,000 lower acquisition value.

Overall, the examination of Hypotheses 4 and 5 suggest that future models of capital investment may need to consider factors traditionally excluded from economic models, such as the extent to which a firm is uncertain about whether its acquisition will fulfill customer desires (i.e. physician preferences, consumer preferences, and care needs). The separation between physician and hospital payment may induce decision makers to be more concerned about customer desires than about the profit of the hospital in which they work. Hospitals may be a unique context in which decision makers are less concerned about the financial well-being of their host firm than they are about how their decisions impact the demand for their firm's services. Nonetheless, this study demonstrates that under some circumstances, customer desires may play a critical role in determining the magnitude of capital investment.

4.2.2: Normative Theory

Hypothesis 4 asserted that measurable, economic characteristics of hospitals would influence the present value of the most valuable CT acquired. I further speculated that more payer contracts, higher operating costs, longer investment durations and lower interest rates would all be associated with the acquisition of a more valuable CT. The results presented in Table 15 show that while in one model, a longer minimum investment lifespan is associated with greater acquisition value, payer contracts, overall property, plant, and equipment, the number of FTEs, the maximum length of the investment, and the interest rate (LIBOR) at the time of investment lack a significant relationship to investment value. Thus, Hypothesis 4 was by and large unsupported.

Insert Table 15 about here

The models testing the influence of the payer contracts factor on acquisition value using the most usable dataset suggested that government control was significantly associated with lower acquisition value. These two models suggested that government hospitals acquired CTs with a present value of about a quarter-million dollars less, after controlling for all of the other factors.

A number of the other control variables were significant as well. Purchasing (rather than leasing) was associated with $380,000 greater acquisition value in the model that examined the influence of the payer contracts factor using the most usable responses. Experiencing an additional brand was associated with a $71,000 more expensive acquisition in the model considering the payer contracts factor using the full dataset. In both of the models run using the full dataset, a greater number of years elapsed since the acquisition was associated with the acquisition having a lower present value (significant at the $p<.10$ level for the model considering payer contracts, and $p<.05$ for the model considering measures of operating costs). This makes sense, as older machines tend to be inferior and worth less than newer ones. In all of the models, Critical Access Hospital status was significantly associated with lower acquisition value. Critical Access Hospitals must by definition be remotely located, and may not need as expensive technologies to attract customers. It is unlikely that in an emergency, a patient needing care would have an alternative to seeking it at a Critical Access Hospital.

Lastly, the results showed some evidence of bias. In the models that included a measure of payer contracts, the ACHE and Texas samples were associated with the acquisition of significantly more expensive CTs (around a quarter-million more expensive) than the RSNA sample. This effect was significant when the full dataset was considered and was nearly significant when only the most usable responses were considered. It is possible that respondents at hospitals whom acquired less expensive most valuable CTs may have been biased towards not answering the survey if they received it in the mail instead of via a live experimenter. Furthermore, response by a physician was associated with the acquisition of a less-expensive CT being reported. This effect was significant in all of the normative models and ranged in size from $275,000 to $375,000, depending on the model. This bias may have been introduced because physicians may be less aware of their hospital's most valuable CT machine than non-physicians whom may have an outlook that spans multiple hospital departments, or even multiple financially-integrated hospitals. Physicians may fail to identify more valuable machines in other departments, and non-physicians may contribute to this bias by improperly answering the survey by considering an offsite CT that is present in a separate but connected hospital, or in a freestanding facility.

4.2.3: Prospect Theory

I explored the influence of uncertainty on acquisition value through a three step exploration. First, to test Hypothesis 5, I ran regressions that examined whether the present value of the acquisition was negatively related to revenue uncertainty and positively related to cost uncertainty (Table 16). No significant relationship was found for the independent variables that were examined. Although Prospect Theory does not make any predictions on how non-financial uncertainty will influence the value of an investment, I examined the influence of the four types of non-financial uncertainty anyway using the full dataset (Table 17) and the most usable responses (Table 18).

Interestingly, for the full dataset, I found that the present value of the most valuable CT machine was significantly and negatively related to both the extent of physician preference, consumer preference, and care uncertainty. A 1 point increase in reported physician preference uncertainty was associated with a $96,000 less expensive acquisition ($85,000 less for the most usable responses). For consumer preferences, a 1 point increase in uncertainty was associated with a $78,000 less expensive acquisition ($63,000 for the most usable responses). The greatest impact came from a 1 point increase in care uncertainty, which was associated with a $100,000 less expensive acquisition ($88,000 for the most usable responses). When considered in aggregate, a 1 point increase in customer desires factor uncertainty was associated with the acquisition of an $113,000 less expensive machine in the full dataset model and the acquisition of a $96,000 less expensive machine in the most usable responses model (Table 19). These findings all suggest that uncertainty about a machine's ability to fulfill customer desires has a substantial financial impact on the outcome of the acquisition. This makes sense, as the customer desires factor may be a measure of uncertainty about how well a CT will attract demand. Demand for the machine may have a greater financial impact on physicians than the revenues and operating costs tied to the hardware itself. Physicians may be behaving in a rational fashion when placing more emphasis on demand uncertainty than on the financial uncertainty that the hospital faces as a result of the acquisition.

Insert Table 16 through Table 19 about here

The general conclusion of these explorations is that it is not clear how the framing of the uncertainty (i.e. as a gain or a loss) influences its impact on the present value of the acquisition. The respondent-perceived measures of financial uncertainty were not significantly related to the value of the acquisitions that their hospitals made. However, a number of the measures of uncertainty related to customer desires were significantly related to the present value of their hospitals' acquisitions. While these forms of uncertainty are not clearly related to gains or losses and thus not very compatible with the framework of Prospect Theory, they are worth noting as they appear to significantly impact hospital acquisition decision making.

Going through the results tables one at a time reveals further details about the factors influencing CT value when self-reported uncertainty is considered in the regression. It should be noted that the regressions tested in this section only differ from those in Section 4.2.2 with respect to their independent variables. The control variables in all of the models are the same, and the dependent variable in all cases is the present value of the most valuable CT machine.

In the models considering respondent-reported revenue and cost uncertainty in Table 16, for-profit status was significantly associated with lower acquisition value – all the models suggested that for-profits acquire machines worth about $300,000 less than non-profits, all else being equal. Once again, survey responses from physicians reported the acquisition of machines worth about a quarter-million dollars less in the models tested using the full dataset. This relationship did not hold for the models tested using the more usable responses. In both of the models tested using the full dataset, hospitals that acquired a new brand of machine got a machine that was worth about $200,000 more (significant at $p<.05$ for the revenue model, and at $p<.075$ for the cost model). The present value of the machines declined at about $74,000 per year, and older machines had significantly lower present values. Once again, Critical Access Hospital status was associated with the acquisition of a significantly less expensive machine, worth about $70,000 less.

As was previously mentioned, Table 17 and Table 18 explore the impact of the four non-financial types of uncertainty on the value of the acquisition. When the either dataset was used, physician preference, consumer preference, and care uncertainty were negatively related to acquisition value. In the full dataset model, the impact of an additional point (on a 7-point Likert scale) of physician preference, consumer preference, and care uncertainty was estimated to be a decrease in CT value of $96,000, $78,000, and $100,000 respectively. When the most usable responses were considered, the impact of an additional point of uncertainty was smaller; $85,000, $63,000, and $88,000 respectively.

Within Table 17 and Table 18, a number of control variables were significant. The control variables that were significant were more or less the same ones that were significant in the models considering financial uncertainty. Once again, for-profit status, physician responses, older year of acquisition, and Critical Access Hospital status were all significantly associated with lower acquisition value in nearly all of the models. The selection of a CT of a new brand was significantly or nearly significantly ($p<.075$) associated with a $200,000 higher acquisition value in all of the models tested using the full dataset.

The tenure of the respondent may have biased the answers as well. In the models tested using the full dataset, each additional year of tenure was significantly associated with an $8,000 less expensive acquisition in the physician preferences factor model, and was associated with a less expensive machine at near significance in the other three models. One possibility is that respondents with longer tenure may have experienced a greater number of previous “most valuable CTs” over the course of their time at their hospital, and may have been more likely to accidently report on one of these prior machines.

Last but not least, it is important to examine Table 19, which examines the impact of the financial factor and customer desires factor on the present value of the acquisition. I examined these attributes via factors as well, as this is how they were considered in the first stage of the model. Although it is not possible to test Prospect Theory using these regressions, as revenues and costs have been merged into the financial factor, these models are worth exploring in that the independent variable in them is the dependent variable from the models run in Section 4.1. As I mentioned previously, among these models, customer desires uncertainty is significantly and negatively related to the present value of the acquisition in both datasets. In the full dataset, a 1 point increase in customer desires uncertainty is significantly related to an $113,000 decrease in acquisition value, while in the more usable dataset, the impact is a $96,000 decrease. The control variables all have relatively the same impact that they do in the models tested without factors.

Overall, these models of the influence of respondent-reported measures of uncertainty on the value of the acquisition suggest that decision maker perceptions of financial uncertainty do not influence the value of the acquisition, while decision maker perceptions of customer desires uncertainty negatively influence the value of the acquisition. This effect is a bit stronger for physician preference uncertainty and care uncertainty than it is for consumer preference uncertainty. Consumer preference uncertainty is both less significant and less impactful on acquisition value than physician preference uncertainty. Uncertainty about the research performance of a machine does not appear to significantly influence the value of an acquisition.

Beyond the influence of uncertainty, several other factors appear to influence the value of the acquisition as well. For-profit status and Critical Access Hospital status were associated with lower acquisition values. For-profit hospitals may select less expensive CT machines with equal clinical benefit, but lower ability to perform non-essential functions, as they have difficulty charging more for the non-essential functions under the Diagnosis Related Group system, and are primarily concerned with profit maximization. Critical Access Hospitals are remotely situated and do not need to invest as extensively in technology as a result of competitive pressures from local rivals. Finally, older acquisitions had significantly lower present values. This is not a surprising finding, as when technologies advance, older versions tend to depreciate.

Chapter 5: Conclusions & Discussion

5.1: Summary of the Findings

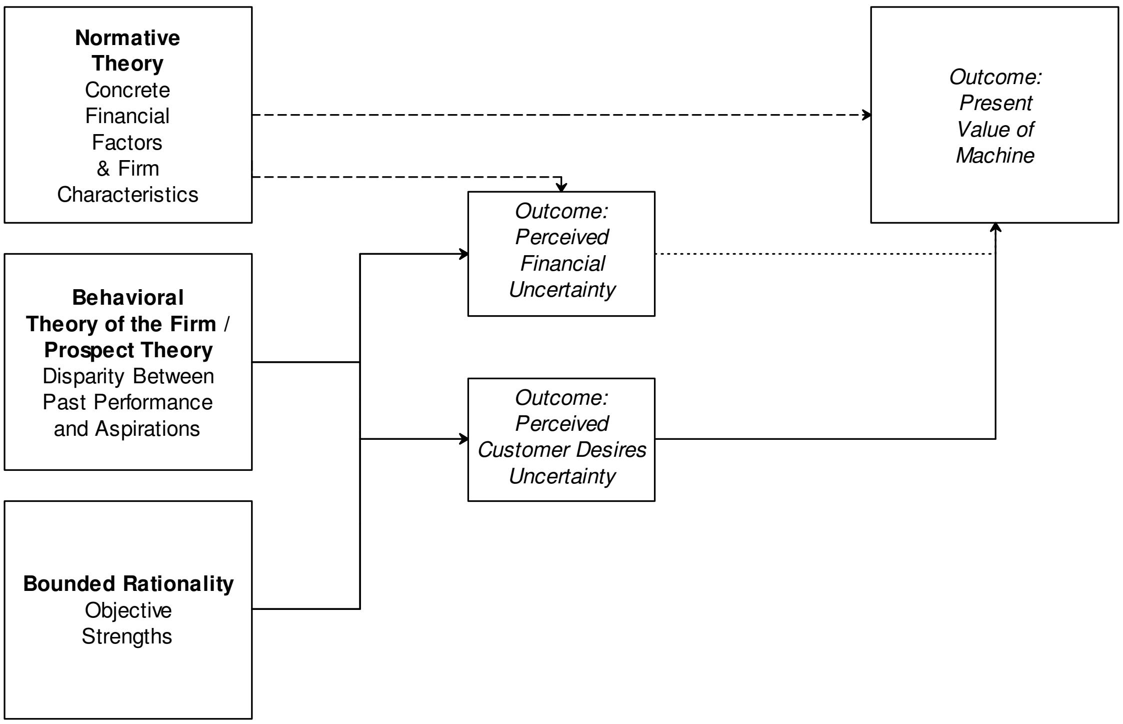


Figure 7: Graphical Summary of the Findings

Figure 7 provides a graphical summary of the findings of this dissertation. The dark lines symbolize supported relationships, the dashed lines symbolize partially supported relationships, and the dotted line symbolizes an unsupported relationship. A more detailed summary of the hypothesized relationships and findings is provided in Table 20. Ultimately, it appears that some of the economic factors have a significant relationship to the degree of financial uncertainty perceived by the firm. Higher values of both disparity measures and objective strength measures were associated with lower corresponding values of perceived financial and customer desires uncertainty, providing support for the findings of the behavioral literature (Cyert & March, 1963; Kahneman & Tversky, 1979) and Bounded Rationality literature (Simon, 1947) on the determinants of firm uncertainty-seeking. The present value of the acquisition was significantly related to some of the economic factors considered, but not to the reported perception of financial uncertainty. The present value of the most valuable CT was most strongly determined by the extent to which the hospital was uncertain about whether it would fulfill customer desires; greater uncertainty related to this factor was associated with lower acquisition values. This is consistent with the statement by Pauly and Burns (2008) that the selection of costly devices is driven by physicians' preferences, and that physicians may be unaware of the absolute or relative prices of the devices they select.

Insert Table 20 about here

These overall findings are somewhat counterintuitive, as they suggest that uncertainty about customer desire fulfillment play a greater role in determining the outcome of the decision making process than does uncertainty about profitability. Furthermore, they suggest that future research should pay more attention to the role of non-financial factors in the capital investment decision making process. Crum and Derkinderen (1981) suggested that many capital investment decisions are not made based upon financial grounds, and Bromiley (1986) suggested that corporate strategy plays a role in investment decisions. However, the role that these non-financial factors play has thus far not received quantitative analysis.

The results also provide information about the determinants of a firm's uncertainty about its investment's ability to fulfill customer desires. Namely, the firms tended to have more uncertainty about the investments ability to fulfill customer desires if they did not consider fulfilling customer desires to be as important an objective. If such firms were constrained in their acquisition research process, as was suggested by Bounded Rationality (Simon, 1947, 1951, 1952/1953, 1955), then they may have redirected their investigative efforts away from reducing customer desires uncertainty, and had more such uncertainty as a result.

Although the finding that reported perceptions of financial uncertainty do not influence the value of the acquisition in a manner supporting Prospect Theory, the finding also does little to disprove it. It is quite possible that there is interfirm inconsistency in whether revenue and cost uncertainty are framed as gains or losses. Although revenues deal with money gained and costs deal with money lost, having lower than expected revenue is a loss, and having lower than expected costs is a gain. While it is unclear whether uncertainty over a machine's ability to fulfill customer desires is in the gains or the losses domain, the data suggest that firms behave in an uncertainty-averse fashion when facing this form of uncertainty.

To conclude, the results of this dissertation do not displace any of the existing theories, but instead highlight areas for future theoretical expansion. Although most of the literature has focused on the impact of economic measures of financial uncertainty on investment, this study demonstrates that perceptions of non-financial uncertainty are more significantly related to levels of investment than perceptions or concrete measures of financial uncertainty. Outside of their impact on decision making theory, these results suggest that decision makers acquiring equipment should make sure to invest effort in understanding the impact of their investments on their customers. As uncertainty about this impact is a larger driver of the ultimate outcome of the process than is financial uncertainty, it deserves to be given strong consideration during the investment decision making process.

5.2: Theoretical Implications

This study has explored the relationships between hospital characteristics, objectives, uncertainties and acquisition value in the context of the purchase of an expensive, durable technology. Although this research may not be generalizable to other domains, it provides an additional empirical example of a situation in which descriptive theories (Behavioral Theory of the Firm, Prospect Theory, and Bounded Rationality) outperform the normative approach that has been used by much of the prior economic literature. In doing so, it paves the way for future empirical studies.

5.2.1: Implications for the Normative Perspective

The exploration of the economic perspective has made some empirical contributions to the economic literature on uncertainty, capital investment, and their determinants. Although the interest rate did not significantly impact the magnitude of the investment, as was suggested by Johnson and Lewellen (1972) and Gorton (1974), in the two normative models run using the most usable responses (Table 15), higher interest rates were associated with lower investment in the model considering payer contracts (p=.051). This model suggested that every 1% increase in the interest rate is associated with acquiring a CT machine worth about $55,000 less.

One debate that has been occurring in the economics literature is on how uncertainty influences capital investment. One group of papers have argued that the two have a negative relationship (Bertola, 1988; Pindyck, 1988; Craine, 1989; Zeira, 1989; Caballero, 1991), while another group have argued that the two have a positive relationship (Hartman, 1972; Pindyck, 1982; Abel, 1983, 1984, 1985). While testing Hypothesis 5, I found that increased perceived uncertainty about an acquisition's ability to fulfill customer desires was associated with decreased investment (Table 19). Thus, this paper provides some empirical support for the existence of a negative relationship.

5.2.2: Implications for the Behavioral Perspective

Through the test of Hypothesis 2, this study provides further confirmation of the assertion held by the main proponents of the Behavioral Theory of the Firm and Prospect Theory—that uncertainty-seeking increases as performance falls below aspirations, and is reduced as performance exceeds aspirations (Cyert & March, 1963; Wright & Kunreuther, 1975; Kahneman & Tversky, 1979; Bromiley, 1991). While there appears to be little relationship between the disparity and uncertainty when the disparity is close to zero, when the disparity diverges far from zero, a significant relationship exists.

Although Hypothesis 5 was not able to tie revenue or cost uncertainty to investment value, it was successful in revealing some interesting relationships between non-financial forms of uncertainty and investment. It is possible that Hypothesis 5 was not able to demonstrate that revenue uncertainty leads to decreased investment and operating cost uncertainty leads to increased investment because firms did not consistently frame revenues as gains and costs as losses. The findings of Hypothesis 2 suggest that firms may have considered actual revenue relative to aspired revenue when judging if there was a "gain" in revenue, and actual costs relative to aspired costs when judging if there was a "loss" from costs, rather than strictly labeling revenues as gains and costs as losses.

Although only one set of tests were conducted for Hypothesis 2, the tests can be framed in the language of Prospect Theory as well as that of the Behavioral Theory of the Firm. Kahneman and Tversky (1979) claimed that decision makers are uncertainty-seeking when experiencing losses and uncertainty-averse when experiencing gains. If the problem of CT acquisition is framed so the status quo is the state the hospital was in before it acquired its prior most valuable CT, and gains and losses for each of the objectives are considered by measuring the difference between their performance and the hospital's aspirations for them at that time, then the overall hypothesis of Prospect Theory holds.

There is a debate in the performance-aspiration disparity literature about whether firms performing below aspiration levels become more uncertainty-averse (Janis & Mann, 1977; Staw, Sandelands, & Dutton, 1981; Sitkin and Pablo, 1992) or more uncertainty-seeking (Cyert & March, 1963; Wright & Kunreuther, 1975; Kahneman & Tversky, 1979; Bowman, 1980, 1982; Bromiley, 1991) the further their performance deviates from their aspiration levels. The results presented in Table 28 and Table 29 and Figure 5 and Figure 6 demonstrate that firms with performance further below aspiration levels seek investments associated with greater degrees of uncertainty. This finding has historically received a greater deal of empirical support than the finding that poorly performing firms become more uncertainty-averse.

There are also potential implications for the rugged landscapes literature. The behavioral literature has traditionally argued that firms tend to satisfice on multiple dimensions, rather than maximizing along one dimension. As a result, they tend to restrict themselves to searching for solutions near their status quo. In searching for solutions, firms have been said to take an incremental, localized approach, rather than making radical leaps (March & Simon, 1958; Cyert & March, 1963). Meanwhile, the rugged landscapes literature has suggested that there may be multiple possible solutions to a problem, some better than others. Firms making incremental change may be optimizing themselves towards the best performance for their solution, but may not by optimizing themselves for the best performance overall. “Long-jumps”, consisting of radical change, are needed for firms to go from optimizing for one solution to optimizing for another (Kauffman, 1993; Levinthal, 1997). When hospitals with poorly performing CTs acquire new ones veiled in a high degree of uncertainty, they may be taking the type of long-jump described by the rugged landscapes literature.

Lastly, this study may also serve as a counter-example to the findings related to Bowman’s Paradox (Bowman, 1980; 1982). The implication of the findings from Hypotheses 2 and 5 considered in conjunction is that when the prior most valuable CT performs below aspirations in fulfilling customer desires, hospitals have greater uncertainty about the extent that their new most valuable CT with fulfill customer desires (Hypothesis 2). High uncertainty about whether a CT will fulfill customer desires is associated with the acquisition of a less expensive machine (Hypothesis 5).

In order to test Bowman's Paradox, I examined the impact of disparities between performance and aspirations on CT value as well (Table 32). The models were structured the same way as the models testing Hypothesis 5, save for the change of independent variable. Neither of the models pertaining to disparity related to the financial factor was significant. As was expected, the relationship was significant for the customer desires factor when the full dataset was used, and nearly significant (p=.075) when the most usable responses were used. An additional point of customer desires performance above the aspiration level was associated with additional acquisition value of between $72,000 (according to the full sample) and $53,000 (according to the more usable sample). This all suggests that hospitals experiencing worse prior performance take on less uncertainty in their subsequent acquisition and acquire a less expensive machine. In contrast, Bowman found that troubled firms take on more risk than their less troubled peers.

5.2.3: Implications for Bounded Rationality

Furthermore, this study provides findings on the relationship between a firm's uncertainties and objectives. Greater importance of both financial and customer desires objectives were associated with reduced uncertainty in the acquisition's ability to fulfill that objective. This finding on the relationship between objective importance and uncertainty suggests that firms may be boundedly rational, and may invest their limited search resources in reducing uncertainty for the attributes that they feel are of the most importance to them (Simon, 1947). This helps refute March's (1978) statement that we avoid our preferences during the decision making process, and specify goals that differ from the outcomes we wish to achieve. The tests of Hypothesis 3 imply that firms do appear to be focusing their efforts to reduce uncertainty on objectives that matter to them. Likewise, less important objectives were associated with greater levels of uncertainty during the decision making process.

5.3: Practical Implications

The results of this study are potentially of interest to several groups of people: decision makers inside and outside of hospitals, equipment manufacturers, and policy makers wishing to influence equipment purchasing. CT machines are very expensive and their increasing utilization is contributing to the increasing cost of healthcare (Hartman, Martin, Nuccio, & Catlin, 2010). While hospitals do not often buy advanced imaging machines, the few decisions that they do make with respect to imaging have the potential to have substantial implications for their own financial performance and, in aggregate, for the financial performance of the industry.

5.3.1: Implications for the Hospital Literature

There has long been a debate in the literature over whether and how a hospital's ownership status influences its behavior, investments, and objectives (Long, 1964; Reder, 1965; Ginsberg, 1970; Feldstein, 1971; Newhouse, 1970; Lee, 1971; Pauly & Redisch, 1973; Burns et al., 2009). As the full sample used in this study contained responses from hospitals of a variety of control types, it was possible to make some comparative assessments. In each of the models, variables for control type were included. As a result, there were a number of findings about the influence of control type. Relative to non-profit status, for-profit status was significantly associated with reduced financial factor uncertainty in several of the models, as well reduced acquisition value. Government status was associated with lower acquisition value than non-profit status in some of the hospitals.

These findings suggest that hospital control type has the potential to influence both the uncertainties a hospital possesses while acquiring equipment and the amount it is ultimately willing to spend. The difference in the objectives of for-profit and non-profit hospitals has received considerable research. This study suggests that such attention is warranted, as control type appears to impact both perceived uncertainty and acquisition value.

One finding of this study that was contrary to much of the literature was the variables related to operating costs (property, plant, and equipment expenditures and FTEs) did not appear to significantly impact the value of the investment. This was in congruence with the findings of Dunkelberg, Furst, and Roenfeldt (1984), but contrary to the findings of Dunn and Lefkowitz (1978), Bentkover, Sloan, Feeley, Campbell, and Firth (1984), and Somers (1989). One possible explanation for this finding is that hospitals did not consider their overall operating costs when deciding which model of machine to acquire, as the machines are more similar in their operating costs than in their fixed costs.

Another finding of this study is that CT machines appear to be physician preference items. The value of a CT acquired is significantly influenced by the degree of uncertainty about whether it will fulfill customer desires, but not by the degree of financial uncertainty surrounding its performance. A line of research has examined the relative financial insensitivity surrounding the purchase of physician preference items. The physician preference item literature has largely focused on the purchase of patient-specific equipment by physicians on behalf of their patients, such as implants, medical devices, orthotics, and stents (DeJohn, 2005). Unlike commodity items, physician preference items are relatively unlikely to be purchased through hospital purchasing alliances (Burns & Lee, 2008). As a result, solutions to reducing expenditures related to physician preference items have looked at implementing rules like formularies and payment caps, rather than solutions that are more applicable to large purchases for which decisions are infrequent and made with managerial involvement (Montgomery & Schneller, 2007). The results of this study suggest that CT machines are also physician preference items. Hospitals may need to continue to devise methods for managing the acquisition of large, infrequently acquired physician preference items, in addition to the smaller, more frequently acquired items that have been more extensively studied.

Future research on hospital investment decision making should improve upon this study by attempting to account for the operating costs of the equipment acquired, instead of the overall operating costs of the hospitals. Hospital control type should continue to be considered as a potential determinant of investment decision making. This study confirms prior empirical and theoretical assertions that for-profit, non-profit, and government hospitals behave slightly differently (Wedig, Hassan, & Sloan, 1989; Duggan, 2000; Cutler, Feldman, & Horwitz, 2005).

5.3.2: Implications for Decision Makers

Hospitals may also be interested in the results of this study because they have historically engaged in “technology wars” with other hospitals. My field interviews revealed that nationally-renowned academic medical centers bought equipment in part to be on par with other nationally-renowned academic medical centers, as they felt that they risked losing faculty if they did not do so. A total of 49 of the responses that I received indicated that their hospitals had acquired their most valuable CT as a response to competitive action. This was the third most popular motive, behind technological developments and capacity expansion (Table 10).

Fortunately, the normative portion of this study has several implications for decision makers. First, this study makes it clear that it is important to realize that there is a connection between managed care contracting and equipment purchasing. While the two tasks are often handled by entirely separate divisions of the hospital, the number of managed care contracts held by hospitals appears to influence the financial uncertainty that decision makers have when making equipment acquisition decisions (Hypothesis 1). Second, there were several financial factors that were not found to be significant. The interest rate at the time of investment was not significant in any of the models (although it came close in one). This may be because the economic factors examined and the questions asked dealt with operating costs, rather than sunk costs. These costs are less likely to be influenced by the interest rate than the cost of the machine. Nonetheless, it was a bit surprising to see that hospitals did not invest in less expensive machines during times of higher interest rates, and that the decision to lease or purchase did not influence the value of the investment. Normatively, hospitals should take the interest rate into account when making an investment, as it will influence their cost of capital if borrowing or their hurdle rate if deciding between multiple investments.

This study is also of value to decision makers because it can help them understand what drives the degree of uncertainty that they are bear to take when making investment decisions. There is strong support for the assertion that firms take more on more uncertainty when in the past they have been underperforming their aspirations and take on less uncertainty when in the past they have been outperforming their aspirations (Hypothesis 2), in accordance with the Behavioral Theory of the Firm and Prospect Theory. The normative theory does not hold as well. The degree of revenue and cost uncertainty the decision makers were willing to take on was not significantly related to many of the underlying characteristics of the hospital. While normatively, one would assume that a hospital with a smaller budget would be less willing to take on a high degree of financial uncertainty than a hospital with a larger budget, the factor corresponding to financial uncertainty had no bearing on the value of the acquisition. Descriptively, hospitals seemed to have taken on more financial uncertainty if their prior equipment had worse than aspired financial performance and less financial uncertainty if their prior equipment's financial performance exceeded aspirations (Hypothesis 2). This finding is surprising, as McNamara and Bromiley (1997) suggested that when decision makers are influenced by both organizational factors and cognitive biases, the influence of the organizational factors outweighs the influence of the cognitive biases.

It is unsurprising that hospital decision makers were influenced more greatly by uncertainty over whether customer desires would be satisfied than by uncertainty over profitability. During my pilot study, I found that respondents were unable to answer basic questions that could be used to estimate profitability, such as the volume of machine utilization. As physician salaries do not have a direct relationship to equipment profitability in a hospital setting, it makes sense that it is not an area of great concern. Physicians generate income by charging for their services in conjunction with the use of a

CT machine – the cost of the machine itself may simply be considered part of the hospital's overhead (GE Healthcare, 2010). Furthermore, there is a descriptive literature that shows that decision makers act in a manner that minimizes personal potential for job loss (Coffee, 1986; Gupta, 1987, Chatterjee & Lubatkin, 1990; Greenwald & Stiglitz, 1990; Wiseman & Gomes-Mejia, 1998). By meeting the needs of their constituents, even at the expense of firm profitability, the decision makers may be acting in a way that is most beneficial to their careers.

There are a number of prescriptions for improving the CT acquisition process that hospitals can glean from this study. Hospitals may wish to more consciously consider the cost of capital in their decision making process. The profitability of an investment is lower if the capital required to finance it is higher due to a higher interest rate. In the majority of the models that were tested, the interest rate did not appear to influence the value of the acquisition. Additionally, the most decisive factor in determining the ultimate value of the acquired machine appears to be the hospital's degree of certainty about whether the machine will meet customer desires. The extent of this uncertainty is influenced by both hospital objectives and the disparity between the hospital's aspiration level and the previous machine's performance. Given that uncertainty about an acquisition's ability to fulfill customer desires appears to play such a decisive role in the ultimate outcome of the decision, it may be prudent for hospitals to over-weight fulfilling customer desires as an objective when deciding how to allocate time investigating machines.

5.3.3: Implications for CT Manufacturers

Ultimately, the goal of manufacturers is to understand their customers so that they can offer products in a more profit-maximizing fashion. If more expensive models also are more profitable (as they tend to be – otherwise there would be no incentive to upsell), manufacturers desire encourage their customers to acquire more expensive machines. The results of this study highlight the factors that cause a hospital to acquire a more costly machine. Manufacturers may also wish to invest more heavily in educating decision makers about how their equipment can meet the needs of physicians and the demands of providing high-quality care. Increased uncertainty related to these two issues was significantly related to lower acquisition value. This study suggests that more educated consuming firms might be willing to spend more.

There are other means of reducing uncertainty related to a machine's ability to fulfill customer desires. By stressing the importance of fulfilling the needs of physicians and patients to purchasers when promoting machines, manufacturers can seek to increase the perceived importance of fulfilling customer desires as an objective. This study has shown that when hospitals perceive an objective to be more important, they tend to also have less uncertainty about their most valuable CT's ability to fulfill it. This may be because hospitals more rigorously investigate objectives that they perceive as more important. Getting hospitals to pay more attention during the decision making process to whether the machines fulfill the desires of their customers may result in the hospitals acquiring more expensive machines.

Although this study did not directly examine the relationship between performance-aspiration disparity and acquisition value, I computed regressions examining this relationship, which I have included as the supplemental tables, Table 30 and Table 31. While the disparity was not significantly related to the acquisition value when the control variables were included, when the model was run without using control variables, prior customer desires performance in excess of aspirations was associated with acquiring a more expensive machine. Thus, there is some empirical support for the linkage between performance-aspiration disparity, uncertainty, and CT value which I have postulated.

5.3.4: Implications for Understanding the Impact of Policy Changes

Finally, the results of this study may be useful in predicting the implications of several forthcoming policy changes. The financial and customer desires uncertainty that hospitals face is likely not static, but instead is in part determined by the environment in which hospitals operate. The spread of Accountable Care Organizations (ACOs), increased price transparency, and increased outcomes research all may have an impact on both the uncertainties that hospitals have when acquiring CTs and on the value of their ultimate acquisitions.

One of the features of the Patient Protection and Affordable Care Act (a.k.a. Obamacare) was the provision for the creation of Accountable Care Organizations (ACOs). Section 3022 of the bill allows ACOs to contract with Medicare and be held accountable for the care, cost of treatment, and quality of treatment received by the fee-for-service Medicare beneficiaries assigned to them. Beneficiaries assigned to ACOs would in effect be put under shadow capitation, with payments to their providers being either increased or reduced depending on how well the providers in the ACO performed relative to local benchmarks (Goldsmith, 2009). As the creation of ACOs may concentrate market power, the Federal Trade Commission has had to issue guidelines for when it will consider ACO activity as anticompetitive (Federal Trade Commission, 2011).

To the extent that ACOs create exogenous uncertainty in revenue, they will increase the financial uncertainty of hospitals acquiring subsequent CT machines. However, if ACOs drive hospitals within geographic areas to collaborate on managing the cost and quality of treatment, they may decrease the demand uncertainty that hospitals face. If an ACO commands a far greater share of the market than any of its constituent hospitals and makes cross-hospital decisions on equipment acquisition, the hospitals may experience less uncertainty in customer demand. This study has shown that an increase in financial uncertainty does not appear to impact the value of CT machines acquired. However, a decrease in uncertainty about consumer preferences is associated with the acquisition of more expensive CTs. Thus, the increased prevalence of ACOs may encourage the acquisition of more expensive CTs, in spite of the increased financial uncertainty that will likely accompany this change.

Another recent development is the increased consideration of policies promoting price transparency. In 2011, 34 states required the reporting of hospital charges or reimbursement rates, and there was increasing pressure for hospitals to be more forthcoming about pricing, particularly formerly confidential pricing information in payer contracts (Cutler & Dafny, 2011). It is unclear whether more transparent pricing will result in lower or higher prices. However, it may cause hospitals to match the prices of their peers, resulting in less price variation (Cutler & Dafny, 2011; Sinaiko & Rosenthal, 2011). In an environment of reduced price variation, hospitals likely have less uncertainty about the revenues that their CT machines will generate. While they may still be uncertain about the volume of patients they will receive for the machine, if prices are coordinated, they will likely be far less uncertain about how much they will be reimbursed. As this study showed that changes in uncertainty related to customer desires are associated with changes in acquisition value, but changes in uncertainty related to revenue are not, increased price transparency may have no significant impact on the value of CT machines that hospitals acquire.

On a related note, manufacturers are facing increasing pressure to disclose the prices that they charge hospitals for equipment (U.S. Senate, 2007; Pauly & Burns, 2008). Medical devices, such as CT machines tend to be sold under differentiated oligopolies, in which a small number of firms sell distinct devices (Pauly & Burns, 2008). In the case of CT, the primary manufacturers are GE, Hitachi, Philips, Siemens, and Toshiba. While mandatory disclosure of average prices might give hospitals more leverage in negotiation and reduce uncertainty related to the sunk costs associated with acquiring equipment, it would not influence uncertainty related to operating costs. As overall hospital property plant, and equipment expenditures at cost did not have a significant impact on the value of the CT acquired, there is no evidence that a policy which reduces the sunk costs associated with other equipment will reduce CT spending. The direct impact of increased CT equipment price transparent on the value of CTs acquired is unexplored in this work.

One form of policy that is likely to influence the value of CTs acquired is policy promoting increased outcomes research. The form of uncertainty found to be most negatively associated with the value of CTs acquired was that related to how well the machines would deliver patient care. The American Recovery and Reinvestment Act of 2009 allocated $1.1 billion to support comparative effectiveness research. Comparative effectiveness research investigates the benefits and harms of diagnosis, prevention, and treatment methods (Sox & Greenfield, 2009). The Patient Protection and Affordable Care Act went on to subsequently create the Patient-Centered Outcomes Research Institute (Kaiser Family Foundation, 2010). If this research achieves its aim, there will ultimately be more information available to decision makers about the impact of different CT machines and procedures on care. Ironically, although comparative effectiveness has been touted as a tool for both increasing quality and reducing costs, hospitals with better information on outcomes may be willing to acquire more expensive CT machines. This study has found that decreased uncertainty over care outcomes is associated with the acquisition of more costly machines.

5.4: Limitations

Although there were several significant findings in this study, there are issues in the methodology that may lead some to question the results. Participants were not randomly selected, but instead were people who either chose to answer a mail survey or both attended a conference and opted to participate. The response rates of the mail samples were rather low, and the demographics of the respondents were not random. Respondents to the Texas survey tended to be radiologists, respondents to the American College of Healthcare Executives survey tended to be hospital administrators, and respondents to Radiological Society of North America survey tended to be either radiologists, radiology technicians, or medical physicists. Given the poor response rate, the willingness of participants to participate may indicate that they more strongly value research—one of the attributes considered by the study.

The low response rate caused additional issues as well. As a result, the sample size used in the study was rather small. Furthermore, the adjusted R^2 of the models was rather poor. The number of variables included in the models had to be somewhat restricted in order to get the models to have reasonable statistical power as the sample size was so small.

There were also issues related to the nature of the data that went into the study. Cross-sectional data was used, all of which was reported after the acquisition being studied had occurred. As a result, respondents may have had trouble recalling the information that they reported, or may have reported it inaccurately. Since the respondents appeared to have trouble recalling facts related to revenue and profitability, and this information was not provided in the American Hospital Association Annual Survey Database, the study was not able to consider profitability. Likewise, it was not possible to obtain information on the characteristics of the key decision makers, except in the cases in which the key decision makers also happened to be the respondents.

Another issue of this study is that of generalizability. In order to make the value of the acquisitions comparable, only one type of acquisition was examined. The findings of this study may not be generalizable to other medical imaging equipment acquisitions, or to acquisitions occurring outside of a hospital setting. Many CT machines are acquired by free-standing clinics, and it is possible that these facilities employ a different decision making process.

Additionally, this study did not consider inter-firm interactions. The control variables included did not account of the CT machines possessed by nearby competing hospitals. While hospital system and network membership was considered as a binary variable, this study did not control for a network effect. If some systems or networks share equipment to a greater extent than others, this may be a factor influencing the value of acquisitions.

Finally, it is important to note that this study was unable to conclusively prove or disprove any theories. Instead, it provided a single-context empirical example in which a series of theories were compared. The results of subsequent studies may differ if different contexts or methodologies are used. There may be issues related to the quality of the indicators used, as there was substantial inter-rater disagreement on a number of them. A fuller picture of the relative performance of the theories in question will only be possible after more comparisons have been made.

Furthermore, there may be relevant theories for explaining uncertainty levels and acquisition values which have not been considered or not yet proposed. For instance, one explanation for acquisition decision making might be institutional theory, which suggests that organizations adopt changes in part due to a drive towards isomorphism out of a desire for legitimacy (Meyer & Rowan, 1977). Coercive, mimetic, and normative forces drive organizations to become increasingly similar (DiMaggio & Powell, 1983). Institutional theory suggests that understanding acquisition decision making requires an understanding of the other firms with which the focal firm is interacting. This is but one of several potential explanations for the acquisition decision making process unexplored in this study.

Despite all these limitations, this study has managed to provide information about the comparative performance of three different perspectives on the determinants of acquisition uncertainty during the firm acquisition decision making process, as well as findings on the comparative performance of two different perspectives of the determinants of the value of firm capital investments. The construction of a novel dataset enabled the testing of a series of issues related to firm capital investment decision making using both publicly-reported and perceived factors internal to the firm. The prior literature has largely looked at outside proxies of firm performance, aspirations, and objectives, rather than directly surveying the people involved in the process.

5.5: Future Research Directions

There is much room for further research on the impact of non-financial uncertainty on the magnitude of capital investments. The impact of non-financial uncertainty on the magnitude of the investment was a bit of a surprise, as none of the theories I considered had predicted that it would have any influence. The surprise in part resulted from the paucity of research on this subject. The uncertainty-investment relationship has not been extensively empirically explored using firm-level data, and as a result, heterogeneity in firm characteristics have largely been ignored (Guiso & Parigi, 1999). The two notable exceptions to this have taken a substantially different approach than this study. Leahy and Whited (1996) looked at the expected variance in the daily stock market returns of firms, and Guiso and Parigi (1999) looked at firms' self-reported uncertainty about the growth in the demand for their products. Neither study looked at an extensive battery of perceptions of uncertainty. As this study demonstrates that non-financial measures of uncertainty, such as employee preference (physician preference), consumer preference, and product quality (care) uncertainty matter, they warrant further research.

This study further suggests that at least in some contexts, non-financial measures of uncertainty may play a larger role in determining the value of a capital investment than the financial measures of uncertainty traditionally studied. Future researchers should conduct studies that consider both perceived and environmentally-determined forms of non-financial uncertainty and attempt to determine if and how they impact capital investment. This study found no significant relationship between uncertainty in the research productivity of an investment and the magnitude of an investment, but was not able to provide a good explanation as to why no relationship was found. Although uncertainty-aversion was found for the other three types of non-financial uncertainty, it is not clear whether that finding is generalizable to other types of non-financial uncertainty. Future researchers can attempt to generalize rules for both determining which forms of perceived non-financial uncertainty impact investments, and how they do so.

Appendix

A.1: Tables

	Any CT	Multislice, <64 Slices	Multislice, 64+ Slices
Nationwide			
Number of Hospitals With:	4,030	2,747	1,552
Number of Hospitals Without:	834	2,105	3,295
Percentage of Hospitals With:	82.9%	56.6%	32.0%
Nationwide, by Control Type			
Non-Federal Government	917	536	137
Non-Profit	2466	1813	1068
For-Profit	567	352	199
Federal Government	80	46	48
Texas			
Number of Hospitals With:	374	250	131
Number of Hospitals Without:	168	292	411
Percentage of Hospitals With:	69.0%	46.1%	24.2%
Texas, by Control Type			
Non-Federal Government	103	58	25
Non-Profit	132	101	58
For-Profit	139	91	48
Federal Government	0	0	0

Table 1: Prevalence of CT in 2008

Variable	**Reliability**
Slices (Current CT)	0.87
Slices (Prior CT)	0.76
Year (Current CT)	0.93
Year (Prior CT)	**0.00**
Purchased (Current CT)	0.82
Purchased (Prior CT)	0.72
Objective Importance - Revenue	0.44
Objective Importance - Costs	**0.16**
Objective Importance - Physician Pref	**0.39**
Objective Importance - Consumer Pref	0.52
Objective Importance - Care	**0.12**
Objective Importance - Research	0.70
Objective Fulfillment Before - Revenue	0.42
Objective Fulfillment Before - Costs	**0.25**
Objective Fulfillment Before - Physician Pref	0.54
Objective Fulfillment Before - Consumer Pref	0.53
Objective Fulfillment Before - Care	0.59
Objective Fulfillment Before - Research	0.44
Uncertainty - Revenue	**0.21**
Uncertainty - Costs	**0.00**
Uncertainty - Physician Pref	0.70
Uncertainty - Consumer Pref	0.59
Uncertainty - Care	0.65
Uncertainty - Research	0.49
Dept. - Key DM Admin	**0.19**
Dept. - Key DM Clinician	**0.32**

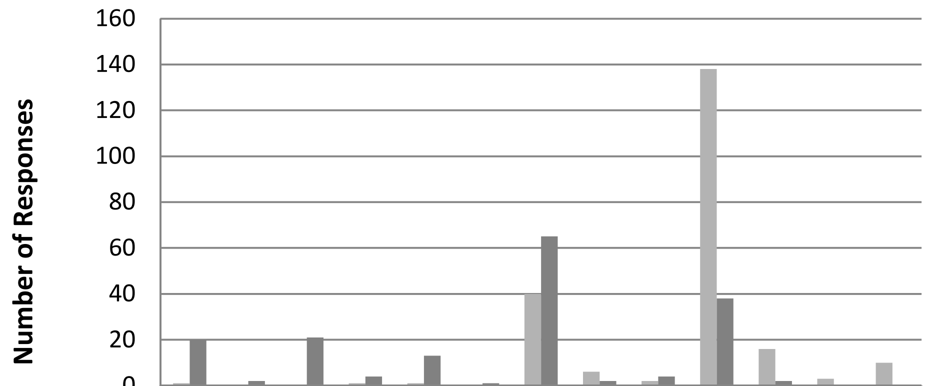
Table 2: The Reliability of Usable Responses from Hospitals with Multiple Respondents
Note: Higher is better.

	Mean	S.D.	0	1	2	3	4	5	6	7	N
Uncertainty - Revenue	5.23	1.42		2%	2%	5%	22%	22%	26%	22%	217
Uncertainty - Costs	5.02	1.32		1%	1%	7%	30%	22%	24%	15%	217
Uncertainty - Physician Pref	5.69	1.31		0%	3%	3%	12%	16%	34%	32%	217
Uncertainty - Consumer Pref	5.35	1.40		1%	2%	6%	20%	16%	32%	23%	215
Uncertainty - Care	5.88	1.24		0%	1%	5%	9%	15%	30%	40%	217
Uncertainty - Research	3.44	2.20		33%	9%	9%	14%	8%	16%	11%	209
Uncertainty - Recall	5.29	1.46		2%	3%	5%	21%	16%	31%	23%	216
Most Valuable CT Value	1.1E+6	5.4E+5									215
Hospital - # HMO Contracts	11.97	27.42									161
Hospital - # PPO Contracts	29.21	33.92									172
Hospital - Total Facility Expenses	3.9E+8	4.8E+8									208
Hospital - Property Plant & Equipment	3.9E+2	2.6E+2									184
Hospital - Total FTEs	2.7E+3	3.0E+3									208
Dept. - Min. Life of CT	6.42	2.30									209
Dept. - Max. Life of CT	9.74	3.00									205
Objective Before - Revenue	4.95	1.49		5%	3%	5%	19%	31%	22%	15%	221
Objective Before - Costs	4.85	1.50		4%	5%	7%	19%	27%	27%	11%	221
Objective Before - Physician Pref	4.87	1.64		4%	5%	12%	17%	22%	22%	19%	221
Objective Before - Consumer Pref	4.59	1.66		6%	5%	11%	25%	20%	19%	14%	221
Objective Before - Care	5.24	1.58		2%	5%	7%	14%	23%	21%	28%	221
Objective Before - Research	2.75	2.02		47%	9%	8%	14%	8%	7%	6%	221
Objective - Revenue	5.57	1.69		5%	2%	6%	9%	12%	26%	40%	221
Objective - Costs	5.22	1.68		3%	5%	9%	14%	18%	20%	31%	221
Objective - Physician Pref	5.86	1.32		1%	2%	2%	9%	17%	28%	41%	221
Objective - Consumer Pref	4.98	1.75		5%	6%	9%	17%	17%	21%	25%	221
Objective - Care	6.46	1.11		1%	0%	1%	4%	5%	18%	71%	221
Objective - Research	2.93	2.12		42%	11%	10%	12%	7%	8%	10%	221
Control - For Profit			91%	9%							221
Control - Government			81%	19%							221
Respondent - Key DM is Administrator			27%	73%							218
Respondent - Is Key DM			61%	39%							218
Respondent - Key DM is MD/DO			52%	52%							221
Respondent - Tenure	11.22	9.38									219
Hospital - System Member?	0.57	0.50	43%	57%							221
Hospital - Network Member?	0.36	0.48	64%	36%							193
Purchased (Current CT)	0.81	0.39	19%	81%							210
Current CT is a New Brand	0.23	0.42	77%	23%							221
Current CT is Same Brand as Prior MVCT	0.50	0.50	50%	50%							221
Experienced - Total Brands	2.45	0.98		18%	36%	32%	13%	2%			221
Years Elapsed Since CT Acquired	2.41	2.20									206
LIBOR (Current CT)	3.00	1.67									206
Hospital - Catholic Church Operated?	0.16	0.37	84%	16%							208
Hospital - Critical Access Hospital	0.05	0.21	95%	5%							208

Table 3: Summary Statistics, Full Sample

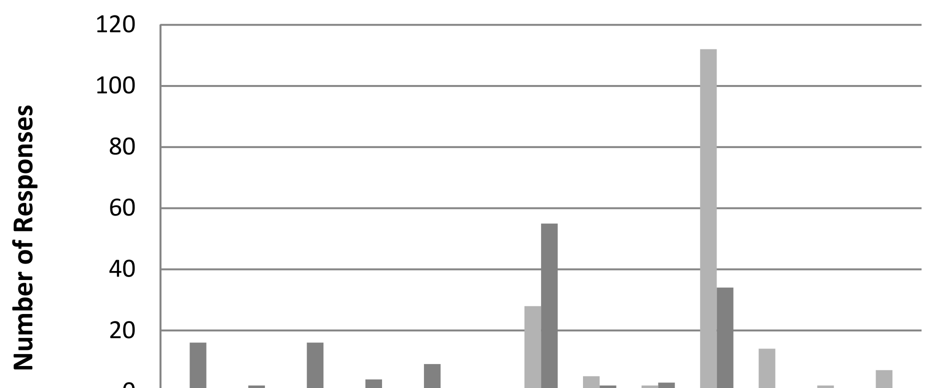
	Mean	S.D.	0	1	2	3	4	5	6	7	N
Uncertainty - Revenue	5.30	1.38		2%	2%	4%	21%	24%	25%	23%	174
Uncertainty - Costs	5.08	1.31		1%	1%	7%	30%	21%	23%	17%	174
Uncertainty - Physician Pref	5.77	1.26		1%	2%	2%	11%	17%	33%	34%	174
Uncertainty - Consumer Pref	5.44	1.39		2%	1%	5%	19%	17%	30%	26%	172
Uncertainty - Care	5.95	1.19		0%	1%	5%	7%	16%	30%	41%	174
Uncertainty - Research	3.43	2.22		33%	10%	8%	13%	8%	13%	12%	172
Uncertainty - Recall	5.32	1.47		2%	4%	4%	19%	15%	32%	23%	175
Most Valuable CT Value	1.1E+6	5.2E+5									170
Hospital - # HMO Contracts	9.13	7.52									126
Hospital - # PPO Contracts	29.09	29.40									137
Hospital - Total Facility Expenses	3.8E+8	5.0E+8									165
Hospital - Property Plant & Equipment	3.9E+2	2.6E+2									146
Hospital - Total FTEs	2.7E+3	3.2E+3									165
Dept. - Min. Life of CT	6.29	2.24									168
Dept. - Max. Life of CT	9.58	2.82									166
Objective Before - Revenue	5.05	1.46		3%	3%	5%	20%	29%	23%	17%	176
Objective Before - Costs	4.95	1.43		3%	4%	7%	19%	28%	25%	13%	176
Objective Before - Physician Pref	4.96	1.60		4%	3%	11%	15%	26%	22%	19%	176
Objective Before - Consumer Pref	4.60	1.66		7%	5%	11%	24%	22%	18%	14%	176
Objective Before - Care	5.32	1.56		2%	5%	6%	12%	24%	21%	29%	176
Objective Before - Research	2.71	2.02		48%	10%	6%	15%	8%	6%	7%	176
Objective - Revenue	5.65	1.63		5%	2%	5%	9%	13%	26%	41%	176
Objective - Costs	5.23	1.71		4%	5%	7%	15%	18%	19%	32%	176
Objective - Physician Pref	5.91	1.34		2%	2%	2%	7%	15%	30%	43%	176
Objective - Consumer Pref	5.08	1.78		5%	7%	9%	14%	15%	23%	27%	176
Objective - Care	6.46	1.16		2%	1%	2%	3%	4%	17%	72%	176
Objective - Research	2.84	2.09		44%	12%	11%	10%	7%	7%	9%	176
Control - For Profit			81%	19%							176
Control - Government			35%	65%							176
Respondent - Key DM is Administrator			25%	75%							173
Respondent - Is Key DM			61%	39%							174
Respondent - Key DM is MD/DO			46%	54%							176
Respondent - Tenure	12.89	9.31									176
Hospital - System Member?	0.60	0.49	40%	60%							176
Hospital - Network Member?	0.36	0.48	64%	36%							152
Purchased (Current CT)	0.83	0.38	17%	83%							165
Current CT is a New Brand	0.23	0.42	77%	23%							176
Current CT is Same Brand as Prior MVCT	0.53	0.50	47%	53%							176
Experienced - Total Brands	2.17	1.96		18%	35%	31%	14%	2%			176
Years Elapsed Since CT Acquired	2.17	1.96									162
LIBOR (Current CT)	2.92	1.64									162
Hospital - Catholic Church Operated?	0.82	0.38	82%	18%							165
Hospital - Critical Access Hospital	0.05	0.23	95%	5%							165

Table 4: Summary Statistics, Most Usable Responses Sample



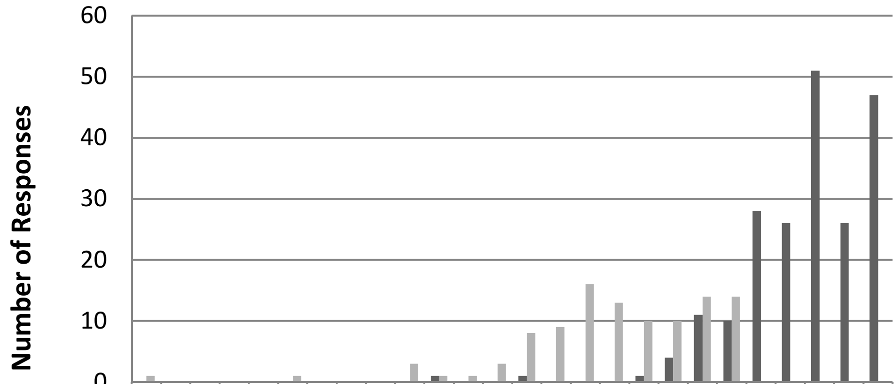
	1	2	4	6	8	10	16	32	40	64	128	256	320
Current Most Valuable CT	1			1	1		40	6	2	138	16	3	10
Prior Most Valuable CT	20	2	21	4	13	1	65	2	4	38	2		

Table 5: Number of Slices in the Current and Prior Most Valuable CT, by Number of Responses (Full Sample)



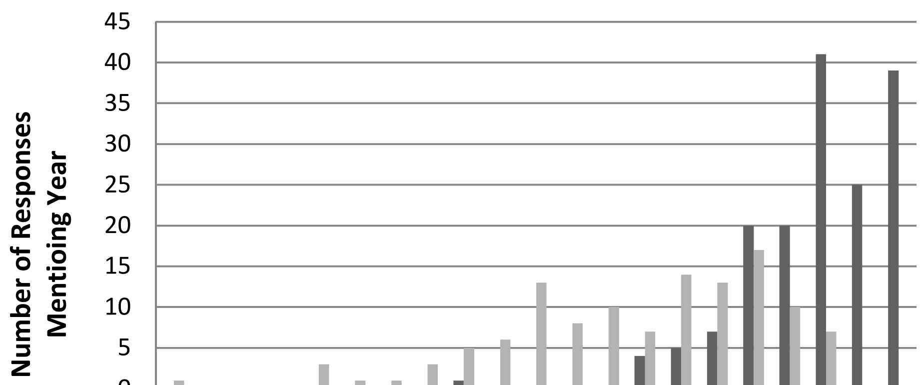
	1	2	4	6	8	10	16	32	40	64	128	256	320
Current Most Valuable CT	1			1			28	5	2	112	14	2	7
Prior Most Valuable CT	16	2	16	4	9	1	55	2	3	34			

Table 6: Number of Slices in the Current and Prior Most Valuable CT, by Number of Responses (Usable Sample)



	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Current Most Valuable CT											1			1				1	4	11	10	28	26	51	26	47
Prior Most Valuable CT	1					1				3	1	1	3	8	9	16	13	10	10	14	14					

Table 7: Year of Acquisition of the Current and Prior Most Valuable CT, by Number of Responses (Usable Sample)



	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Current Most Valuable CT									1					4	5	7	20	20	41	25	39
Prior Most Valuable CT	1				3	1	1	3	5	6	13	8	10	7	14	13	17	10	7		

Table 8: Year of Acquisition of the Current and Prior Most Valuable CT, by Number of Responses (Full Sample)

	Any CT	Multislice, <64 Slices	Multislice, 64+ Slices
Nationwide			
Number of Hospitals With:	4,030	2,747	1,552
Number of Hospitals Without:	834	2,105	3,295
Percentage of Hospitals With:	82.9%	56.6%	32.0%
Nationwide, by Control Type			
Non-Federal Government	917	536	137
Non-Profit	2466	1813	1068
For-Profit	567	352	199
Federal Government	80	46	48
Texas			
Number of Hospitals With:	374	250	131
Number of Hospitals Without:	168	292	411
Percentage of Hospitals With:	69.0%	46.1%	24.2%
Texas, by Control Type			
Non-Federal Government	103	58	25
Non-Profit	132	101	58
For-Profit	139	91	48
Federal Government	0	0	0

Table 9: CT Ownership by Machine Type and Control Type

Motive	Frequency
Capacity expansion	82
Competitive action	49
Contract expiration	9
Leadership changes	6
Tech developments	94

Table 10: Frequency of Reported Motives for CT Acquisition

Please note that some of the hospitals in Table 10 provided multiple responses, although the prompt was to report the primary motive.

Factor: Model: Dataset:	Financial Economic Full	Financial Disparity Full	Financial Objective Full	Financial Economic Usable	Financial Disparity Usable	Financial Objective Usable
Adjusted R^2	0.100	0.308	0.350	0.140	0.335	0.388

Factor: Model: Dataset:	Customer Economic Full	Customer Disparity Full	Customer Objective Full	Customer Economic Usable	Customer Disparity Usable	Customer Objective Usable
Adjusted R^2		0.139	0.158		0.152	0.193

Table 11: Comparison of the Adjusted R^2 of the Uncertainty Models

	Financial Uncertainty Full	Financial Uncertainty Usable
Hospital - Payer Contracts Factor	-0.00116 (0.672)	0.0117 (0.229)
Hospital - PP&E at Cost	0.00000582 (0.990)	0.000198 (0.730)
Hospital - Total FTEs	0.0000132 (0.704)	0.0000133 (0.716)
Dept. - Min. Life of CT	0.115 (0.102)	0.00167 (0.986)
Dept. - Max. Life of CT	-0.0888* (0.037)	-0.0233 (0.690)
Control - For Profit	-0.433 (0.334)	-0.711 (0.163)
Control - Government	0.270 (0.469)	0.0325 (0.941)
Respondent - Key DM is Admin	-0.214 (0.446)	-0.0494 (0.886)
Respondent - Key DM	0.308 (0.242)	0.213 (0.392)
Respondent - MD/DO	-1.145*** (0.001)	-1.241** (0.001)
Respondent - Tenure	0.00586 (0.668)	0.0151 (0.327)
Hospital - System Member?	-0.275 (0.247)	-0.444 (0.072)
Hospital - Network Member?	-0.0674 (0.793)	0.145 (0.587)
Purchased (Current CT)	0.302 (0.298)	0.513 (0.195)
Current CT is a New Brand	0.317 (0.415)	0.400 (0.435)
Current CT is Same Brand as Prior MVCT	-0.0103 (0.970)	0.166 (0.651)
Experienced - Total Brands	0.0736 (0.584)	0.103 (0.514)
Years Elapsed Since MVCT Acquired	-0.0453 (0.332)	-0.0940 (0.156)
LIBOR (Current CT)	-0.0262 (0.704)	-0.0373 (0.660)
Hospital - Catholic Church Operated?	-0.413 (0.183)	-0.667 (0.060)
Hospital - Critical Access Hospital	0.480 (0.384)	0.561 (0.415)
Source - ACHE	-0.158 (0.674)	0.138 (0.751)
Source - Other	0.468 (0.243)	0.856 (0.059)
Source - Texas	-0.0788 (0.810)	0.208 (0.594)
Constant	3.409*** (0.000)	2.630** (0.001)
Observations	121	96
Adjusted R-squared	0.100	0.140

Table 12: Impact of Normative Factors on Financial Uncertainty

	Financial Uncertainty Full	Customer Desires Uncertainty Full	Financial Uncertainty Usable	Customer Desires Uncertainty Usable
Disparity - Factor	-0.394*** (0.000)	-0.287*** (0.000)	-0.433*** (0.000)	-0.274** (0.004)
Control - For Profit	-0.688* (0.028)	-0.500 (0.158)	-0.985** (0.001)	-0.519 (0.151)
Control - Government	0.0905 (0.652)	-0.370 (0.113)	0.0132 (0.959)	-0.329 (0.215)
Respondent - Key DM is Admin	-0.0873 (0.676)	-0.00499 (0.981)	-0.0716 (0.770)	-0.125 (0.588)
Respondent - Key DM	0.283 (0.107)	0.194 (0.284)	0.222 (0.243)	0.0686 (0.700)
Respondent - MD/DO	-0.827*** (0.000)	-0.278 (0.195)	-0.845** (0.002)	-0.454 (0.069)
Respondent - Tenure	0.00377 (0.669)	-0.00836 (0.318)	0.00380 (0.716)	-0.00881 (0.406)
Hospital - System Member?	-0.0407 (0.824)	0.241 (0.302)	-0.0729 (0.736)	0.182 (0.485)
Hospital - Network Member?	-0.128 (0.458)	-0.322 (0.103)	0.0452 (0.829)	-0.163 (0.428)
Purchased (Current CT)	0.0272 (0.890)	0.0475 (0.815)	0.188 (0.482)	0.0530 (0.835)
Current CT is a New Brand	-0.155 (0.552)	-0.376 (0.167)	-0.211 (0.505)	-0.321 (0.280)
Current CT is Same Brand as Prior MVCT	-0.180 (0.383)	-0.305 (0.204)	-0.205 (0.391)	-0.233 (0.327)
Experienced - Total Brands	0.0602 (0.526)	0.0439 (0.659)	0.0728 (0.519)	-0.00362 (0.973)
Years Elapsed Since MVCT Acquired	0.00572 (0.874)	0.0564 (0.235)	0.00243 (0.967)	0.129 (0.059)
LIBOR (Current CT)	-0.121* (0.017)	-0.0757 (0.243)	-0.107 (0.089)	-0.124 (0.125)
Hospital - Catholic Church Operated?	-0.319 (0.132)	-0.307 (0.216)	-0.486* (0.034)	-0.407 (0.068)
Hospital - Critical Access Hospital	0.0111 (0.984)	0.671 (0.198)	0.120 (0.852)	0.929 (0.083)
Source - ACHE	-0.173 (0.394)	-0.235 (0.298)	-0.106 (0.663)	-0.0172 (0.945)
Source - Other	0.693** (0.007)	0.457 (0.095)	0.823** (0.006)	0.527 (0.076)
Source - Texas	-0.0292 (0.903)	-0.145 (0.619)	0.186 (0.477)	0.0441 (0.890)
Constant	5.583*** (0.000)	4.277*** (0.000)	5.567*** (0.000)	4.323*** (0.000)
Observations	166	164	130	128
Adjusted R-squared	0.308	0.139	0.335	0.152

Table 13: Impact of Performance-Aspiration Disparity (BTOF/PT) on Uncertainty

	Financial Uncertainty Full	Customer Desires Uncertainty Full	Financial Uncertainty Usable	Customer Desires Uncertainty Usable
Objective Strength - Factor	-0.410*** (0.000)	-0.399*** (0.000)	-0.414*** (0.000)	-0.378** (0.003)
Control - For Profit	-0.495 (0.139)	-0.208 (0.503)	-0.661 (0.058)	-0.160 (0.604)
Control - Government	-0.126 (0.528)	-0.309 (0.169)	-0.117 (0.640)	-0.286 (0.271)
Respondent - Key DM is Admin	-0.0400 (0.846)	0.0354 (0.872)	0.0594 (0.786)	0.0844 (0.723)
Respondent - Key DM	0.0689 (0.673)	0.140 (0.421)	-0.00790 (0.962)	0.0509 (0.746)
Respondent - MD/DO	-0.526* (0.024)	-0.169 (0.475)	-0.766** (0.005)	-0.365 (0.141)
Respondent - Tenure	0.00230 (0.813)	-0.0145 (0.106)	0.00233 (0.836)	-0.0147 (0.184)
Hospital - System Member?	-0.0566 (0.768)	0.223 (0.344)	-0.173 (0.420)	0.0745 (0.772)
Hospital - Network Member?	-0.0705 (0.679)	-0.278 (0.137)	0.142 (0.490)	-0.142 (0.461)
Purchased (Current CT)	0.0549 (0.776)	0.120 (0.583)	0.0494 (0.845)	0.00541 (0.982)
Current CT is a New Brand	-0.0194 (0.936)	-0.207 (0.444)	-0.0106 (0.970)	-0.144 (0.621)
Current CT is Same Brand as Prior MVCT	-0.0988 (0.580)	-0.183 (0.436)	-0.00576 (0.979)	-0.0867 (0.722)
Experienced - Total Brands	0.0197 (0.834)	0.0230 (0.823)	0.0218 (0.836)	-0.0321 (0.765)
Years Elapsed Since MVCT Acquired	0.0205 (0.586)	0.0655 (0.173)	0.0296 (0.636)	0.117 (0.097)
LIBOR (Current CT)	-0.0664 (0.210)	-0.0306 (0.643)	-0.0724 (0.253)	-0.0493 (0.519)
Hospital - Catholic Church Operated?	-0.420 (0.072)	-0.156 (0.560)	-0.530* (0.032)	-0.269 (0.244)
Hospital - Critical Access Hospital	0.232 (0.625)	0.668 (0.187)	0.288 (0.595)	0.727 (0.190)
Source - ACHE	-0.197 (0.378)	-0.0908 (0.683)	0.0701 (0.780)	0.217 (0.329)
Source - Other	0.662* (0.049)	0.296 (0.460)	0.936** (0.006)	0.492 (0.232)
Source - Texas	0.0182 (0.935)	-0.0898 (0.743)	0.280 (0.293)	0.202 (0.520)
Constant	5.602*** (0.000)	4.815*** (0.000)	5.479*** (0.000)	4.728*** (0.000)
Observations	166	164	130	128
Adjusted R-squared	0.350	0.158	0.388	0.193

Table 14: Impact of Objective Strength on Uncertainty

	CT Value Payer Contracts Full	CT Value Operating Costs Full	CT Value Payer Contracts Usable	CT Value Operating Costs Usable
Hospital - Payer Contracts Factor	-885.0 (0.298)		2717.1 (0.311)	
Hospital - PP&E at Cost		87.87 (0.663)		160.9 (0.498)
Hospital - Total FTEs		10.84 (0.499)		4.310 (0.780)
Dept. - Min. Life of CT	19404.6 (0.540)	-10149.3 (0.697)	65075.8* (0.024)	14486.5 (0.581)
Dept. - Max. Life of CT	-22096.0 (0.238)	-4992.4 (0.792)	-30579.5 (0.134)	-3620.9 (0.870)
Control - For Profit	-374544.5** (0.010)	-285434.5* (0.037)	-544681.3*** (0.000)	-334391.2* (0.016)
Control - Government	-222539.9 (0.064)	33721.6 (0.824)	-280097.4* (0.028)	81831.0 (0.646)
Respondent - Key DM is Admin	-16707.3 (0.892)	15958.7 (0.882)	-170484.4 (0.066)	-128358.8 (0.237)
Respondent - Key DM	66022.1 (0.426)	47581.5 (0.540)	147565.6 (0.081)	119240.1 (0.132)
Respondent - MD/DO	-272313.3* (0.013)	-272865.3* (0.021)	-372840.0** (0.003)	-296195.3* (0.044)
Respondent - Tenure	-2891.1 (0.535)	-3534.7 (0.432)	3569.4 (0.393)	-1910.6 (0.652)
Hospital - System Member?	12110.9 (0.903)	-63403.1 (0.498)	147451.7 (0.115)	69236.4 (0.477)
Hospital - Network Member?	-1798.1 (0.987)	-26501.3 (0.786)	-24138.2 (0.793)	-53568.3 (0.601)
Purchased (Current CT)	21745.1 (0.880)	-131383.4 (0.370)	379995.7*** (0.000)	73685.0 (0.588)
Current CT is a New Brand	212723.4 (0.124)	216728.6 (0.068)	132248.5 (0.472)	118293.1 (0.432)
Current CT is Same Brand as Prior MVCT	-30750.5 (0.768)	49394.6 (0.624)	-228346.0 (0.092)	-116117.5 (0.376)
Experienced - Total Brands	-7659.8 (0.857)	8477.5 (0.842)	70794.9* (0.041)	46729.1 (0.277)
Years Elapsed Since MVCT Acquired	-42777.1 (0.077)	-61883.1* (0.046)	-35739.8 (0.185)	-52857.0 (0.138)
LIBOR (Current CT)	-8065.8 (0.784)	-23939.8 (0.435)	-55229.0 (0.051)	-59920.7 (0.120)
Hospital - Catholic Church Operated?	48804.2 (0.660)	28906.8 (0.796)	-46453.8 (0.709)	-8676.8 (0.940)
Hospital - Critical Access Hospital	-779476.4*** (0.000)	-812041.8*** (0.000)	-652239.1*** (0.000)	-793586.6*** (0.000)
Source - ACHE	242427.3* (0.044)	102634.7 (0.413)	262842.1 (0.060)	67861.3 (0.652)
Source - Other	170823.2 (0.123)	37279.9 (0.776)	93904.2 (0.414)	9196.1 (0.949)
Source - Texas	272100.2* (0.047)	59443.0 (0.689)	134440.1 (0.340)	-76269.0 (0.606)
Constant	1439255.2*** (0.000)	1633212.7*** (0.000)	968705.6*** (0.000)	1449432.3*** (0.000)
Observations	125	145	98	115
Adjusted R-squared	0.129	0.125	0.293	0.134

Table 15: Impact of Normative Factors on CT Value

	CT Value Revenue Full	CT Value Cost Full	CT Value Revenue Usable	CT Value Cost Usable
Uncertainty - Factor	-40748.9 (0.092)	-3880.9 (0.895)	-19591.6 (0.491)	24679.1 (0.487)
Control - For Profit	-287278.3* (0.016)	-290627.0* (0.013)	-325132.7** (0.005)	-295635.2* (0.015)
Control - Government	-67866.0 (0.568)	-76981.9 (0.522)	-22035.3 (0.871)	-24151.7 (0.855)
Respondent - Key DM is Admin	42669.1 (0.653)	48516.1 (0.614)	-70237.2 (0.444)	-71712.4 (0.443)
Respondent - Key DM	71933.4 (0.345)	68449.2 (0.369)	125355.4 (0.089)	122907.8 (0.092)
Respondent - MD/DO	-266558.3* (0.018)	-226764.1* (0.050)	-254655.8 (0.069)	-206020.8 (0.157)
Respondent - Tenure	-5266.1 (0.185)	-5026.2 (0.208)	-2143.5 (0.567)	-2194.4 (0.546)
Hospital - System Member?	-95086.2 (0.262)	-88857.1 (0.299)	19747.2 (0.846)	34390.3 (0.728)
Hospital - Network Member?	12487.5 (0.879)	16403.4 (0.842)	-39374.8 (0.689)	-49276.9 (0.616)
Purchased (Current CT)	-96257.1 (0.466)	-89754.8 (0.510)	27067.9 (0.850)	21996.2 (0.880)
Current CT is a New Brand	209917.2* (0.049)	196117.9 (0.072)	92897.7 (0.427)	79421.7 (0.511)
Current CT is Same Brand as Prior MVCT	1329.7 (0.988)	-479.8 (0.996)	-114135.4 (0.298)	-115375.7 (0.302)
Experienced - Total Brands	-913.2 (0.980)	-1089.8 (0.977)	37130.9 (0.319)	34073.2 (0.357)
Years Elapsed Since MVCT Acquired	-74125.5** (0.007)	-73883.9** (0.009)	-55879.9 (0.101)	-50931.8 (0.125)
LIBOR (Current CT)	-19843.6 (0.456)	-17565.2 (0.516)	-49263.4 (0.128)	-49359.8 (0.124)
Hospital - Catholic Church Operated?	31591.8 (0.766)	33261.9 (0.758)	-15477.4 (0.883)	12898.0 (0.904)
Hospital - Critical Access Hospital	-716010.4*** (0.000)	-711428.9*** (0.000)	-673554.0*** (0.000)	-672448.5*** (0.000)
Source - ACHE	13580.2 (0.905)	14977.9 (0.895)	43508.6 (0.760)	36732.8 (0.794)
Source - Other	93358.0 (0.406)	72865.8 (0.537)	43814.6 (0.737)	1580.6 (0.991)
Source - Texas	110006.4 (0.411)	118263.5 (0.367)	-19842.5 (0.884)	-32388.2 (0.816)
Constant	1735529.3*** (0.000)	1598425.3*** (0.000)	1618298.8*** (0.000)	1474276.0*** (0.000)
Observations	163	163	127	127
Adjusted R-squared	0.201	0.190	0.172	0.172

Table 16: Impact of Reported Financial Uncertainty on CT Value

	CT Value Physician Pref. Full	CT Value Cons. Pref. Full	CT Value Care Full	CT Value Research Full
Uncertainty - Factor	-95872.8*** (0.000)	-78054.6** (0.004)	-99848.9*** (0.000)	-20283.3 (0.301)
Control - For Profit	-328750.3** (0.003)	-353876.8** (0.002)	-331587.0** (0.004)	-264455.2* (0.030)
Control - Government	-123490.9 (0.290)	-126686.5 (0.262)	-126714.6 (0.287)	-64675.8 (0.628)
Respondent - Key DM is Admin	83850.4 (0.379)	53402.4 (0.574)	60199.3 (0.519)	56005.8 (0.563)
Respondent - Key DM	62885.2 (0.395)	84633.2 (0.262)	73735.7 (0.326)	66584.3 (0.412)
Respondent - MD/DO	-253218.7* (0.017)	-272589.6** (0.009)	-251400.4* (0.019)	-223278.2* (0.041)
Respondent - Tenure	-7670.5* (0.047)	-5986.6 (0.124)	-7139.9 (0.080)	-5273.1 (0.191)
Hospital - System Member?	-58937.9 (0.482)	-68682.3 (0.414)	-71602.6 (0.373)	-89964.1 (0.289)
Hospital - Network Member?	-21324.1 (0.801)	16267.5 (0.846)	9611.1 (0.904)	17388.5 (0.841)
Purchased (Current CT)	-79131.1 (0.538)	-78394.2 (0.536)	-80473.5 (0.525)	-108009.2 (0.446)
Current CT is a New Brand	176156.6 (0.088)	197938.4 (0.074)	214138.3* (0.040)	223145.7 (0.050)
Current CT is Same Brand as Prior MVCT	-16890.5 (0.842)	-41103.2 (0.638)	-6102.4 (0.941)	6612.8 (0.942)
Experienced - Total Brands	4971.4 (0.892)	499.8 (0.989)	1976.4 (0.957)	-871.2 (0.983)
Years Elapsed Since MVCT Acquired	-75735.4** (0.005)	-74288.0** (0.009)	-74559.3** (0.006)	-74771.7** (0.009)
LIBOR (Current CT)	-10653.8 (0.678)	-23977.8 (0.388)	-13881.6 (0.575)	-13112.6 (0.644)
Hospital - Catholic Church Operated?	7666.8 (0.937)	-35939.0 (0.726)	-1147.1 (0.990)	49149.4 (0.648)
Hospital - Critical Access Hospital	-664599.2*** (0.000)	-673505.7*** (0.000)	-614053.7*** (0.000)	-715082.5*** (0.000)
Source - ACHE	-4029.5 (0.972)	9421.6 (0.934)	-4245.1 (0.970)	19805.7 (0.871)
Source - Other	105322.3 (0.323)	97072.1 (0.358)	117262.0 (0.277)	84619.4 (0.466)
Source - Texas	86253.3 (0.517)	85126.2 (0.522)	121812.3 (0.334)	135894.7 (0.303)
Constant	1813847.9*** (0.000)	1866735.6*** (0.000)	1802745.2*** (0.000)	1663559.9*** (0.000)
Observations	163	161	163	155
Adjusted R-squared	0.242	0.234	0.246	0.185

Table 17: Impact of Reported Non-Financial Uncertainty on CT Value, Full Sample

	CT Value Physician Pref. Usable	CT Value Cons. Pref. Usable	CT Value Care Usable	CT Value Research Usable
Uncertainty - Factor	-84635.1** (0.008)	-62869.6* (0.025)	-87545.3* (0.014)	8576.7 (0.686)
Control - For Profit	-347077.4** (0.003)	-364657.6** (0.001)	-362598.3** (0.002)	-313106.2* (0.011)
Control - Government	-64108.2 (0.630)	-46056.6 (0.726)	-69551.4 (0.608)	34352.4 (0.818)
Respondent - Key DM is Admin	-35106.8 (0.707)	-68225.2 (0.445)	-58766.6 (0.522)	-77371.9 (0.417)
Respondent - Key DM	105435.3 (0.153)	122480.6 (0.100)	125901.1 (0.092)	99928.5 (0.209)
Respondent - MD/DO	-268952.9* (0.040)	-285235.7* (0.029)	-269920.6* (0.042)	-222216.1 (0.091)
Respondent - Tenure	-4143.1 (0.266)	-2682.4 (0.463)	-3579.6 (0.397)	-2012.5 (0.599)
Hospital - System Member?	45009.3 (0.645)	49620.4 (0.610)	23659.3 (0.806)	52638.7 (0.564)
Hospital - Network Member?	-59492.4 (0.545)	-38295.3 (0.698)	-21236.4 (0.828)	-32592.2 (0.759)
Purchased (Current CT)	25502.7 (0.854)	39741.2 (0.775)	33259.9 (0.808)	67489.8 (0.626)
Current CT is a New Brand	91809.0 (0.422)	100810.0 (0.418)	125481.1 (0.295)	124240.2 (0.330)
Current CT is Same Brand as Prior MVCT	-110700.3 (0.303)	-137153.8 (0.222)	-105161.2 (0.324)	-102986.5 (0.380)
Experienced - Total Brands	36195.5 (0.338)	32109.2 (0.382)	34935.2 (0.356)	41434.2 (0.327)
Years Elapsed Since MVCT Acquired	-53246.1 (0.089)	-52918.1 (0.134)	-58315.1 (0.073)	-53654.7 (0.126)
LIBOR (Current CT)	-45058.2 (0.135)	-54654.6 (0.114)	-47535.1 (0.114)	-49281.7 (0.163)
Hospital - Catholic Church Operated?	-45087.4 (0.667)	-69242.1 (0.504)	-72217.8 (0.505)	2284.8 (0.983)
Hospital - Critical Access Hospital	-627863.4*** (0.000)	-625373.0*** (0.000)	-587079.2*** (0.000)	-661643.9*** (0.000)
Source - ACHE	40891.0 (0.770)	49685.7 (0.723)	48424.3 (0.734)	31519.2 (0.828)
Source - Other	67848.1 (0.595)	54949.5 (0.666)	88388.0 (0.508)	9463.8 (0.941)
Source - Texas	-28863.9 (0.828)	-48367.9 (0.725)	11452.7 (0.931)	-32082.6 (0.820)
Constant	1750084.9*** (0.000)	1772200.2*** (0.000)	1744622.6*** (0.000)	1435887.1*** (0.000)
Observations	127	125	127	119
Adjusted R-squared	0.211	0.204	0.212	0.151

Table 18: Impact of Reported Non-Financial Uncertainty on CT Value, Usable Responses Sample

	CT Value Financial Full	CT Value Customer D. Full	CT Value Financial Usable	CT Value Customer D. Usable
Uncertainty - Factor	-30934.9 (0.277)	-113067.6*** (0.000)	731.3 (0.983)	-96002.7** (0.004)
Control - For Profit	-300518.1* (0.010)	-353266.1** (0.002)	-320247.6** (0.006)	-369460.8** (0.002)
Control - Government	-74428.1 (0.533)	-140338.8 (0.225)	-20725.5 (0.878)	-68718.3 (0.605)
Respondent - Key DM is Admin	46239.8 (0.627)	70366.2 (0.455)	-68700.6 (0.455)	-52232.6 (0.566)
Respondent - Key DM	72597.1 (0.339)	75589.3 (0.309)	123700.7 (0.093)	115378.3 (0.120)
Respondent - MD/DO	-253832.8* (0.027)	-271695.6* (0.010)	-229020.9 (0.116)	-290152.6* (0.027)
Respondent - Tenure	-5078.9 (0.201)	-7354.1 (0.058)	-1985.1 (0.590)	-3803.9 (0.322)
Hospital - System Member?	-93417.2 (0.273)	-58821.4 (0.475)	29272.4 (0.772)	47648.9 (0.625)
Hospital - Network Member?	14312.1 (0.862)	2836.7 (0.973)	-44101.0 (0.656)	-33396.9 (0.734)
Purchased (Current CT)	-88870.2 (0.505)	-75012.1 (0.552)	28793.3 (0.841)	38378.0 (0.780)
Current CT is a New Brand	202397.1 (0.059)	201852.1 (0.059)	89353.5 (0.457)	116001.3 (0.339)
Current CT is Same Brand as Prior MVCT	-2918.9 (0.974)	-29877.4 (0.720)	-115195.2 (0.302)	-122548.6 (0.255)
Experienced - Total Brands	13.66 (1.000)	1988.8 (0.956)	35678.2 (0.335)	32304.8 (0.390)
Years Elapsed Since MVCT Acquired	-74949.1** (0.008)	-75806.2** (0.006)	-55020.8 (0.108)	-54916.6 (0.097)
LIBOR (Current CT)	-18797.8 (0.484)	-16161.9 (0.534)	-48581.1 (0.133)	-49992.3 (0.118)
Hospital - Catholic Church Operated?	24222.1 (0.822)	-26353.0 (0.786)	-9412.2 (0.930)	-79482.5 (0.454)
Hospital - Critical Access Hospital	-712523.1*** (0.000)	-637277.7*** (0.000)	-674122.6*** (0.000)	-597636.4*** (0.000)
Source - ACHE	11332.3 (0.921)	-4425.1 (0.969)	36643.5 (0.799)	45106.1 (0.748)
Source - Other	89006.2 (0.440)	113199.6 (0.281)	23285.5 (0.865)	77207.6 (0.549)
Source - Texas	115435.0 (0.383)	87131.6 (0.504)	-24773.7 (0.857)	-31094.1 (0.815)
Constant	1697163.4*** (0.000)	1896165.2*** (0.000)	1547823.9*** (0.000)	1813797.1*** (0.000)
Observations	163	161	127	125
Adjusted R-squared	0.194	0.254	0.169	0.220

Table 19: Impact of Reported Factor Uncertainty on CT Value

Hypothesis 1: Uncertainty during the acquisition is influenced by measurable, non-psychological internal and external hospital characteristics.						
Hypothesis	**Dep. Variable**	**Ind. Variable**	**Expected**	**Observed**	**Significant?**	**Support?**
1	Financial U.	Payer Contracts	-	-/+	N/N	N
1	Financial U.	PP&E at Cost	-	+/+	N/N	N
1	Financial U.	Total FTEs	-	+/+	N/N	N
1	Financial U.	Min. Life of CT	+	+/+	N/N	N
1	Financial U.	Max. Life of CT	+	-/+	Y/N	N

Hypothesis 2: Uncertainty during the acquisition is negatively influenced by the disparity between the firm's aspirations for the prior acquisition and the performance of that acquisition.						
Hypothesis	**Dep. Variable**	**Ind. Variable**	**Expected**	**Observed**	**Significant?**	**Support?**
2	Financial U.	Financial D.	-	-/-	Y/Y	Y
2	Customer Des. U.	Customer Des. D.	-	-/-	Y/Y	Y

Hypothesis 3: Uncertainty during the acquisition is negatively influenced by the objectives the firm held for the acquisition.						
Hypothesis	**Dep. Variable**	**Ind. Variable**	**Expected**	**Observed**	**Significant?**	**Support?**
3	Financial U.	Financial D.	-	-/-	Y/Y	Y
3	Customer Des. U.	Customer Des. D.	-	-/-	Y/Y	Y

Hypothesis 4: The present value of the acquisition is influenced by measurable, non-psychological internal and external hospital characteristics.						
Hypothesis	**Dep. Variable**	**Ind. Variable**	**Expected**	**Observed**	**Significant?**	**Support?**
4	CT Val. (Payer)	Payer Contracts	+	-/+	N/N	N
4	CT Val. (Payer)	Min. Life of CT	+	+/+	N/Y	Y
4	CT Val. (Payer)	Max. Life of CT	+	-/-	N/N	N
4	CT Val. (Op. Costs)	PP&E at Cost	+	+/+	N/N	N
4	CT Val. (Op. Costs)	Total FTEs	+	+/+	N/N	N
4	CT Val. (Op. Costs)	Min. Life of CT	+	-/+	N/N	N
4	CT Val. (Op. Costs)	Max. Life of CT	+	-/-	N/N	N

Hypothesis 5: The present value of the acquisition is influenced by the acquirer's perceived uncertainty about the acquisition before it takes place.						
Hypothesis	**Dep. Variable**	**Ind. Variable**	**Expected**	**Observed**	**Significant?**	**Support?**
5	CT Val. (Revenue)	Revenue Uncertainty	-	-/-	N/N	N
5	CT Val. (Cost)	Cost Uncertainty	+	-/+	N/N	N

Table 20: Summary of Findings

When interpreting this table, note that the observed signs and significance levels are reported in the format (full dataset / most usable responses dataset). If either of the datasets yields a significant relationship with the proper sign, support is said to be found.

A.2: Supplemental Tables

Variable	ACHE	Other	RSNA	Texas
Control - For Profit	0.030303	0.1153846	0.0487805	0.212766
Respondent - Key DM is Admin	0.8923077	0.64	0.6790123	0.6595745
Hospital - System Member?	0.4393939	0.5384615	0.597561	0.7446809
Hospital - Critical Access Hospital	0.1076923	0.12	0	0
Uncertainty - Financial	2.414063	2.92	3.08642	3.106383
Objective Strength - Financial	5.719697	6.134615	5.097561	5.06383
Hospital - Total Facility Expenses	2.28E+08	2.17E+08	4.81E+08	5.63E+08
Hospital - Total FTEs	1748.215	1802.2	3305.696	3618.744
Uncertainty - Revenue	2.296875	2.84	3.024691	2.93617
Uncertainty - Cost	2.53125	3	3.148148	3.276596

Table 21: Comparison of Sample Means for Samples with Significantly Different Means

Economic - Full	# HMO Contracts	# PPO Contracts	PP&E at Cost	Total FTEs
# HMO Contracts	1			
# PPO Contracts	0.64***	1		
PP&E at Cost	0.060	-0.020	1	
Tot. FTEs	0.046	0.11	0.088	1
Payer Contracts	0.88***	0.93***	0.018	0.080

Table 22: Economic Variables Correlation Table - Full Dataset

Economic - Usable Responses	# HMO Contracts	# PPO Contracts	PP&E at Cost	Total FTEs
# HMO Contracts	1			
# PPO Contracts	0.37***	1		
PP&E at Cost	-0.11	-0.076	1	
Tot. FTEs	0.18*	0.11	0.090	1
Payer Contracts	0.56***	0.98***	-0.091	0.12

Table 23: Economic Variables Correlation Table - Usable Responses Dataset

Disparity - Full	Revenue	Costs	Physician Preferences	Consumer Preferences	Care	Research	*Customer Desires*
Revenue	1						
Costs	0.71***	1					
Physician Preferences	0.51***	0.48***	1				
Consumer Preferences	0.49***	0.40***	0.66***	1			
Care	0.54***	0.52***	0.75***	0.55***	1		
Research	0.21**	0.22***	0.33***	0.30***	0.30***	1	
Customer Desires	0.58***	0.53***	0.92***	0.84***	0.87***	0.36***	1
Financial	0.92***	0.92***	0.53***	0.49***	0.57***	0.23***	0.60***

Table 24: Disparity Variables Correlation Table - Full Dataset

Disparity - Usable Responses	Revenue	Costs	Physician Preferences	Consumer Preferences	Care	Research	*Customer Desires*
Revenue	1						
Costs	0.75***	1					
Physician Pref	0.57***	0.49***	1				
Consumer Pref	0.52***	0.39***	0.66***	1			
Care	0.59***	0.54***	0.74***	0.51***	1		
Research	0.20**	0.22**	0.31***	0.25***	0.26***	1	
Customer Desires	0.64***	0.54***	0.92***	0.84***	0.86***	0.32***	1
Financial	0.94***	0.93***	0.57***	0.48***	0.60***	0.23**	0.63***

Table 25: Disparity Variables Correlation Table – Usable Responses Dataset

Objective Strength - Full	Revenue	Costs	Physician Preferences	Consumer Preferences	Care	Research	*Customer Desires*
Revenue	1						
Costs	0.59***	1					
Physician Pref	0.1	0.17**	1				
Consumer Pref	0.38***	0.25***	0.51***	1			
Care	0.22**	0.24***	0.52***	0.44***	1		
Research	-0.0055	0.058	0.19**	0.15*	0.13*	1	
Customer Desires	0.31***	0.28***	0.82***	0.85***	0.75***	0.20**	1
Financial	0.89***	0.89***	0.16*	0.36***	0.26***	0.029	0.33***

Table 26: Objective Strength Variables Correlation Table - Full Dataset

Objective Strength - Usable Responses	Revenue	Costs	Physician Preferences	Consumer Preferences	Care	Research	*Customer Desires*
Revenue	1						
Costs	0.64***	1					
Physician Pref	0.1	0.16*	1				
Consumer Pref	0.38***	0.24**	0.52***	1			
Care	0.26***	0.23**	0.55***	0.45***	1		
Research	0.053	0.079	0.22**	0.15*	0.15*	1	
Customer Desires	0.32***	0.26***	0.82***	0.86***	0.76***	0.21**	1
Financial	0.90***	0.91***	0.14	0.34***	0.27***	0.073	0.32***

Table 27: Objective Strength Variables Correlation Table - Usable Responses Dataset

Uncertainty - Full	Revenue	Costs	Physician Preferences	Consumer Preferences	Care	Research	*Customer Desires*
Revenue	1						
Cost	0.64***	1					
Physician Pref.	0.38***	0.37***	1				
Consumer Pref.	0.44***	0.37***	0.68***	1			
Care	0.46***	0.46***	0.79***	0.63***	1		
Research	0.047	0.097	0.21**	0.18**	0.21**	1	
Customer Desires	0.48***	0.45***	0.92***	0.87***	0.89***	0.23**	1
Financial	0.91***	0.90***	0.42***	0.45***	0.51***	0.078	0.51***

Table 28: Uncertainty Variables Correlation Table - Full Dataset

Uncertainty - Usable Responses	Revenue	Costs	Physician Preferences	Consumer Preferences	Care	Research	*Customer Desires*
Revenue	1						
Cost	0.70***	1					
Physician Pref.	0.40***	0.35***	1				
Consumer Pref.	0.46***	0.36***	0.69***	1			
Care	0.47***	0.46***	0.78***	0.63***	1		
Research	0.042	0.16*	0.20*	0.18*	0.21**	1	
Customer Desires	0.50***	0.43***	0.92***	0.88***	0.89***	0.22**	1
Financial	0.92***	0.92***	0.41***	0.45***	0.51***	0.11	0.51***

Table 29: Uncertainty Variables Correlation Table - Usable Responses Dataset

	Uncertainty					
Perf-Asp.	Revenue	Costs	Physician Pref	Consumer Pref	Care	Research
-3	3*** (0.000)	1.939*** (0.000)	1.278* (0.012)	1.203** (0.004)	1.233 (0.080)	2.709*** (0.000)
-2	0.143 (0.773)	-0.228 (0.554)	0.096 (0.819)	-0.145 (0.731)	0.385 (0.347)	1.363** (0.002)
-1	0.273 (0.507)	0.00152 (0.996)	-0.482 (0.129)	0.0364 (0.908)	-0.0583 (0.871)	1.142* (0.013)
1	-0.103 (0.667)	-0.664** (0.006)	-0.151 (0.573)	-0.178 (0.498)	0.00667 (0.980)	-0.665 (0.139)
2	-0.633* (0.014)	-1.086*** (0.000)	-0.660* (0.015)	-0.864** (0.001)	-0.368 (0.177)	-1.054* (0.028)
3	-1.212*** (0.000)	-1.321*** (0.000)	-1.186*** (0.000)	-1.254*** (0.000)	-0.974*** (0.000)	-2.030*** (0.000)
Constant	-1.000*** (0.000)	-0.439* (0.000)	-1.278*** (0.000)	-1.036*** (0.000)	-1.567*** (0.000)	-0.613* (0.000)
Observations Adjusted R-squared	217 0.278	217 0.213	217 0.138	215 0.160	217 0.122	209 0.527

Table 30: Performance-Aspiration Disparity vs. Uncertainty, Full Sample

	Uncertainty					
Perf-Asp.	Revenue	Costs	Physician Pref	Consumer Pref	Care	Research
-3	3.779*** (0.000)	2.922*** (0.000)	1.069 (0.067)	1.363** (0.003)	1.167 (0.163)	2.784*** (0.000)
-2	0.0286 (0.955)	0.588 (0.222)	0.436 (0.419)	-0.337 (0.492)	0.333 (0.458)	1.575*** (0.001)
-1	0.154 (0.735)	0.0498 (0.895)	-0.631 (0.076)	0.0575 (0.870)	-0.0606 (0.885)	1.601** (0.003)
1	-0.0106 (0.967)	-0.512* (0.048)	-0.197 (0.501)	-0.0534 (0.852)	0.178 (0.553)	-0.522 (0.295)
2	-0.646* (0.017)	-1.025*** (0.000)	-0.833** (0.006)	-0.804** (0.009)	-0.306 (0.320)	-1.308* (0.020)
3	-1.205*** (0.000)	-1.151*** (0.000)	-1.155*** (0.000)	-1.277*** (0.000)	-0.922** (0.002)	-1.974*** (0.000)
Constant	-1.029*** (0.000)	-0.588** (0.003)	-1.269*** (0.000)	-1.163*** (0.000)	-1.667*** (0.000)	-0.692* (0.020)
Observations Adjusted R-squared	174 0.297	174 0.231	174 0.136	172 0.173	174 0.128	166 0.544

Table 31: Performance-Aspiration Disparity vs. Uncertainty, Usable Responses

	CT Value Financial Full	CT Value Customer D. Full	CT Value Financial Usable	CT Value Customer D. Usable
Disparity - Factor	39384.5 (0.089)	72423.0** (0.004)	763.7 (0.978)	53085.9 (0.075)
Control - For Profit	-247360.5* (0.030)	-240908.0* (0.021)	-315479.9** (0.009)	-268989.3* (0.014)
Control - Government	-75559.3 (0.516)	-106525.7 (0.352)	-21384.7 (0.874)	-47547.8 (0.722)
Respondent - Key DM is Admin	36060.2 (0.705)	59046.2 (0.548)	-67746.5 (0.463)	-29786.5 (0.757)
Respondent - Key DM	61251.4 (0.409)	63715.6 (0.384)	123106.0 (0.092)	115557.5 (0.112)
Respondent - MD/DO	-248441.8* (0.022)	-258709.7* (0.014)	-229647.9 (0.092)	-253299.0 (0.055)
Respondent - Tenure	-4363.1 (0.266)	-5813.9 (0.133)	-1962.2 (0.589)	-2917.2 (0.436)
Hospital - System Member?	-85630.8 (0.320)	-87459.1 (0.277)	28198.5 (0.786)	8581.3 (0.930)
Hospital - Network Member?	21648.2 (0.791)	32484.3 (0.683)	-45028.0 (0.642)	-36630.8 (0.700)
Purchased (Current CT)	-93115.3 (0.489)	-78977.3 (0.553)	29158.7 (0.839)	17361.3 (0.903)
Current CT is a New Brand	214338.7* (0.046)	241612.9* (0.024)	91240.7 (0.442)	149824.3 (0.241)
Current CT is Same Brand as Prior MVCT	7617.8 (0.929)	22267.8 (0.790)	-113982.4 (0.309)	-79287.7 (0.482)
Experienced - Total Brands	3594.0 (0.922)	7577.9 (0.834)	36694.0 (0.314)	38466.1 (0.307)
Years Elapsed Since MVCT Acquired	-76489.1** (0.007)	-76308.6** (0.007)	-55126.4 (0.103)	-61911.5 (0.068)
LIBOR (Current CT)	-14674.6 (0.587)	-11223.5 (0.669)	-48095.5 (0.138)	-37807.4 (0.229)
Hospital - Catholic Church Operated?	-3151.1 (0.977)	-24132.7 (0.819)	-10276.2 (0.921)	-33294.0 (0.757)
Hospital - Critical Access Hospital	-704249.2*** (0.000)	-711609.5*** (0.000)	-675715.9*** (0.000)	-711289.8*** (0.000)
Source - ACHE	36470.8 (0.745)	69273.0 (0.534)	39810.5 (0.786)	92581.3 (0.530)
Source - Other	16898.6 (0.885)	10873.1 (0.920)	23325.3 (0.853)	32834.3 (0.790)
Source - Texas	104489.8 (0.416)	123013.4 (0.311)	-25716.1 (0.848)	-1275.3 (0.992)
Constant	1388369.7*** (0.000)	1178034.6*** (0.000)	1541364.3*** (0.000)	1225759.5*** (0.000)
Observations	167	167	129	129
Adjusted R-squared	0.198	0.227	0.172	0.193

Table 32: The Influence of Performance-Aspiration Disparity on CT Value

A.3: Instrument

UNIVERSITY *of* PENNSYLVANIA

Study on CT System Buying and Leasing

This study is being conducted to gather data for a Ph.D. dissertation.

Please only respond to this survey if you are employed in a hospital and were involved in the decision to purchase the current most valuable CT system.

CTs require substantial investment, but we know little about how hospitals acquire them. CTs may impact hospital revenues, costs, and quality of care. This survey will improve understanding of CT buying and leasing. Participants will receive early access to the results of the study.

Please provide your e-mail address if you wish to receive a copy of the findings:

Your answers will remain confidential.

It is estimated that this survey will take under 7 minutes to complete.

Thank you for your assistance,

Mitchell D. Schnall, M.D., Ph.D.
Matthew J. Wilson Professor of Research Radiology
Hospital of the University of Pennsylvania

Adam C. Powell

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Wharton
UNIVERSITY *of* PENNSYLVANIA

LDI
Leonard Davis Institute
of Health Economics

Special thanks to the Mack Center for Technological Innovation for funding this research.

Boxes for dependent variables are black, control variables are dark gray, and independent variables are light gray. White boxes are for variables not included in the models.

The Most Valuable CT System

The "most valuable CT system" in your hospital is the machine with the greatest resale value.

H4 & H5

	Current Most Valuable CT System	**Prior Most Valuable CT System**
Manufacturer:		
Number of slices:		
Quantity owned:		
Model:		
Year acquired:		
Leased or Purchased?:	☐ *Leased* ☐ *Purchased*	☐ *Leased* ☐ *Purchased*

Briefly state in your own words why your hospital acquired the current most valuable CT:

Which of the following was the strongest motive for the acquisition of the current most valuable CT?:

☐ *Capacity expansion* ☐ *Competitive action* ☐ *Contract expiration* ☐ *Leadership changes* ☐ *Tech developments*

Before the acquisition occurred, did your department perceive that it would be profitable? ☐ *Yes* ☐ *No*

Importance of Objectives for the Current Most Valuable CT

At the time of the acquisition of the current most valuable CT, how **important** to your **radiology department's leadership** were each of the following objectives for the machine?

H3

		1	2	3	4	5	6	7	
Maximizing **revenue**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very important*
Minimizing **operating costs**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very important*
Satisfying **physician preferences**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very important*
Satisfying **consumer preferences**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very important*
Providing high-quality **patient care**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very important*
Performing novel **research**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very important*
Since the acquisition, has your **radiology department's leadership** changed its objectives for CT?	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Substantially*

Experience with CT Systems

Check all that apply.

Manufacturer:	GE	Hitachi	Philips	Siemens	Toshiba	Other
CT currently installed at hospital	☐	☐	☐	☐	☐	☐
CT formerly installed at hospital	☐	☐	☐	☐	☐	☐
CT experienced during prior employment	☐	☐	☐	☐	☐	☐
Hospital rents mobile CT of this brand	☐	☐	☐	☐	☐	☐

Page 1

Vendor Relationship

		1	2	3	4	5	6	7	
Do you feel that the **vendor** of your most valuable CT adds **value**?	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Absolutely*
What is your perception of the overall **quality** of the **hardware and software** sold by the vendor of your most valuable CT?	*Very bad*	☐	☐	☐	☐	☐	☐	☐	*Very good*
What is your perception of the overall **quality of the service** offered by the **vendor** of your most valuable CT?	*Very bad*	☐	☐	☐	☐	☐	☐	☐	*Very good*

Degree to Which Objectives Were Fulfilled Before the Acquisition

Before your hospital obtained its current most valuable CT system, from the perspective of your **radiology department's leadership**, how well did its CT systems meet its objectives of:

H 2

		1	2	3	4	5	6	7	
Maximizing **revenue**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Minimizing **operating costs**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Satisfying **physician preferences**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Satisfying **consumer preferences**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Providing high-quality **patient care**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Performing novel **research**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*

Degree to Which Objectives Are Now Fulfilled

Now, from the perspective of your **radiology department's leadership,** how well do your hospital's CT systems meet its objectives of:

		1	2	3	4	5	6	7	
Maximizing **revenue**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Minimizing **operating costs**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Satisfying **physician preferences**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Satisfying **consumer preferences**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Providing high-quality **patient care**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*
Performing novel **research**	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very well*

Pre-purchase Uncertainty

Before your hospital obtained its most valuable CT system, how certain was your **radiology department's leadership** of the CT's ability to meet the following objectives?:

H 1 & H 2 & H 3 & H 5

		1	2	3	4	5	6	7	
Maximizing **revenue**	*Very uncertain*	☐	☐	☐	☐	☐	☐	☐	*Very certain*
Minimizing **operating costs**	*Very uncertain*	☐	☐	☐	☐	☐	☐	☐	*Very certain*
Satisfying **physician preferences**	*Very uncertain*	☐	☐	☐	☐	☐	☐	☐	*Very certain*
Satisfying **consumer preferences**	*Very uncertain*	☐	☐	☐	☐	☐	☐	☐	*Very certain*
Providing high-quality **patient care**	*Very uncertain*	☐	☐	☐	☐	☐	☐	☐	*Very certain*
Performing novel **research**	*Very uncertain*	☐	☐	☐	☐	☐	☐	☐	*Very certain*
How well do you feel you recalled these uncertainties?	*Very poorly*	☐	☐	☐	☐	☐	☐	☐	*Very well*

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Satisfaction

From the perspectives of the following groups, **how satisfactory is the most valuable CT?**

		1	2	3	4	5	6	7	
Radiology department leadership:	*Unsatisfactory*	☐	☐	☐	☐	☐	☐	☐	*Very satisfactory*
Radiology department staff:	*Unsatisfactory*	☐	☐	☐	☐	☐	☐	☐	*Very satisfactory*
Hospital leadership:	*Unsatisfactory*	☐	☐	☐	☐	☐	☐	☐	*Very satisfactory*

Your Background and Role in the Acquisition (Buying or Leasing) Process

Position: ☐

Degrees (MD, Ph.D, MBA, etc.): ☐

Do you have an administrative role in your department (such as Chair)? ☐ *Yes* ☐ *No (purely clinical)*

The key decision maker in your hospital's CT acquisition process is a: ☐ *Administrator* ☐ *Clinician*

Are you the key decision maker in your hospital's CT acquisition process?: ☐ *Yes* ☐ *No*

What year did you join your present hospital?: ☐

		1	2	3	4	5	6	7	
How strongly do you feel that your continued employment is affected by your CT acquisition recommendations?:	*Not at all*	☐	☐	☐	☐	☐	☐	☐	*Very strongly*

Your Hospital

Name of your hospital: ☐

Estimated minimum lifespan of a typical CT system at your hospital: ☐

Estimated maximum lifespan of a typical CT system at your hospital: ☐

Does your hospital participate in a buying group for CT machines?: ☐ *Yes* ☐ *No*

If *"Yes,"* how does it view the prices advertised by the buying group?: ☐ *Fair prices* ☐ *Max prices*

Is your most valuable CT system **accessible to multiple departments?** ☐ *Yes* ☐ *No*

Does your radiology department maintain a **profit and loss (P&L) statement?** ☐ *Yes* ☐ *No*

Survey Confidence		1	2	3	4	5	6	7	
Rate your confidence in the responses on this survey.	*Not confident*	☐	☐	☐	☐	☐	☐	☐	*Very confident*

Survey serial number: For office use only.

Note: This survey is confidential. Only the experimenter will be able to determine the correspondence between hospitals and responses. Being able to identify the hospital of the respondent enables us to offer a shorter survey by allowing us to merge responses to this survey with data from other sources.

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